Vol. 12 No. 1

# The PROGRESSIVE FISH-CULTURIST

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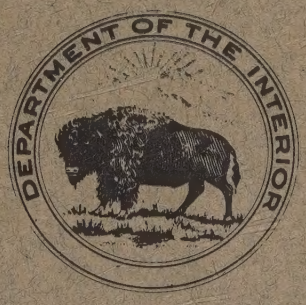


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UNITED STATES DEPARTMENT OF THE INTERIOR
FISH AND WILDLIFE SERVICE

# THE PROGRESSIVE FISH-CULTURIST

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# The PROGRESSIVE FISH-CULTURIST

News and Views from many Sources on Practical Hatchery Problems

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# FISH POPULATIONS IN SOME IOWA FARM PONDS

## A SURVEY BASED UPON TWO METHODS OF POPULATION ANALYSIS

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WITH THE great increase in the number of farm ponds in recent years, there is need for more information on the proper management of these ponds to provide better fishing. The present study deals with a survey of 37 ponds in southern Iowa. Two methods of population analysis, the Swingle method and the Petersen marking and recovery method, were used in several of the ponds to determine the advantages of each method.

The Swingle method (Anderson 1948) depends upon the presence of young fish in midsummer, as determined with a minnow seine. If young-of-the-year largemouth black bass and bluegills were present, the pond was considered to be in balance. If no young-of-the-year largemouth bass and very few young-of-the-year bluegills were to be found, and the seine contained little except 2- to 3-inch yearling bluegills, the pond was classed as being overpopulated with bluegills. When the seine contained no young-of-the-year bass, a few young-of-the-year bluegills, and no 2- to 3-inch yearling bluegills, an overpopulation of the largemouth bass was indicated. If there were no young-of-the-year of either largemouth bass or bluegills, but yearlings of other species were present, the pond was classed as being overpopulated with other species. Of the 37 ponds analyzed by this method, 4 could not be classified because in 2 the population had been poisoned, in 1 the population had winter-killed, and in 1 pond the population had just been stocked the previous fall and had not yet reproduced. Of the remaining 33 ponds, 45 percent were in a balanced condition; 21 percent were overpopulated with bluegills; 10 percent were overpopulated with bass; and 24 percent were overpopulated with other species of fish (table 1). There was some indication that chances of overpopulation with bluegills and other species of fish increased with the age of the fish population in the pond.

Physical conditions of the ponds offered very little hindrance in applying the Swingle method, as a short net was used only along the margins of the ponds. Interpretation of the findings was sometimes difficult, however, particularly after the middle of August. At this time young largemouth bass were large enough to elude the small net and therefore the interpretation depended more on the presence of young bluegills. The total length of the smallest bluegills usually ranged from 1½ to 3 inches. If they were regarded as slower-growing yearlings, the pond would be classed as overpopulated.

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Mr. Fessler is now with the U. S. Soil Conservation Service, Nashville, Illinois.--The EDITORS.

TABLE 1.--Condition, as indicated by the Swingle method, in 1948 of ponds stocked different years

| Condition | Date of stocking 1943 | 1944 | 1945 | 1946 | 1947 | No record | All years combined |
|---|---|---|---|---|---|---|---|
| | Percent | | | | | | |
| In balance | 33 | 67 | 63 | 38 | - | 43 | 45 |
| Overpopulated with bluegills | 33 | 33 | 25 | 13 | 100 | - | 21 |
| Overpopulated with bass | - | - | 13 | 25 | - | - | 10 |
| Overpopulated with other species | 33 | - | - | 25 | - | 57 | 24 |
| Total number of ponds | 6 | 3 | 8 | 8 | 1 | 7 | 33 |

Fast-growing young were often as large in August as slow-growing yearlings.

In analyzing ponds which further study indicated were overpopulated with bullheads, the condition was not readily detected by the Swingle method. Ponds No. 8, 4, and 1 were classed as being overpopulated with bluegills, while the complete population estimate showed the presence of an abundant bullhead population (table 2). There was some difficulty in detecting the presence of crappie by the Swingle method. Being of the semi-carnivorous type, the crappies tend to hold the forage fish in check but not so efficiently as the largemouth bass.

For comparison, the Petersen marking and recapture method was used to obtain an estimate of the number of fish in each pond where it was possible to do so. This method of population estimate is based on the proportion of recaptured fish from a known number of marked fish in a pond. The ratio of the number of marked fish in a pond to the total number of fish in the pond, is assumed to be equal to the ratio of the number of marked fish recaptured to the total number of fish (marked and unmarked) captured. As the total number of fish is the only unknown, the value of the unknown can be determined algebraically. Several modifications for the calculation of the population from these data have been devised (Schnabel 1938). In this study the formulae by Schumacher and Eschmeyer (1943) were used.

A basic assumption in this method is that marked fish will be mixed uniformly with the unmarked fish throughout the pond and will be equally subject to capture. Because the ponds analyzed in the present study were about 1 acre in surface area and the seining usually covered the area of the pond, it seems reasonable to assume that the marked fish were well distributed and gave a representative sampling. Each pond was seined with either a 60-foot net having a 12-foot bag or a 70- by 10-foot (3/8-inch mesh) straight seine. There appeared to be no difference in the efficiency of the two nets in trapping fish.

Before the fish were returned to the water, the total length of each fish was recorded. All the fish except the bullheads were marked at this time by clipping the left pectoral fin; to avoid clipping the spine in the pectoral fin of the bullheads, these fish were marked by clipping the left pelvic fin. The measurements and number of each species of fish were kept separately. As a large percentage of the fish must be marked to obtain reliable results when using this method, sampling continued until numerous previously marked fish were recaptured. On the average, three seine hauls were made to mark a sufficient number of fish.

To permit the marked fish to become redistributed over the entire pond, further seining was not attempted until the next day. The next day the same type

TABLE 2.--Estimated fish populations in various ponds

[Standard error of estimate, expressed as percentage of estimate, in parentheses]

| Pond No. | Largemouth bass | Bluegill | Bullhead | Other species | Species not abundant enough to estimate |
|---|---|---|---|---|---|
| **Ponds with balanced populations[1]** | | | | | |
| 36 | [2]* | 86 (6) | * | [3]126 (8) | Channel catfish, carp, sucker, bluntnose minnow. |
| 33 | 29 (15) | 281 (25) | - | - | - |
| 18 | * | 163 (4) | - | - | - |
| 17 | 54 (12) | 323 (11) | - | - | - |
| 16 | * | 244 (11) | 94 (14) | [3]26 (34)<br>[4]* | Carp, buffalo, orange-spotted sunfish. |
| 2 | 4 (25) | 3,917 (40) | - | [3]* | Fathead minnow. |
| **Ponds overpopulated with bluegill[1]** | | | | | |
| 15 | 12 (5) | 351 (7) | - | [5]22 (33) | - |
| 9 | 95 (55) | 156 (6) | - | - | - |
| 8 | - | 333 (18) | 845 (13) | [5]* | - |
| 4 | * | 155 (32) | 593 (75) | [5]124 (35) | - |
| 3 | 8 (70) | 325 (44) | 155 (32) | [3]221 (23)<br>[5]* | Bluntnose minnow. |
| 1 | 22 (68) | 347 (5) | 236 (37) | [6]84 (95) | - |
| **Ponds overpopulated with bass[1]** | | | | | |
| 35 | 21 (57) | 76 (27) | - | [4]* | - |
| 34 | 18 (17) | 296 (3) | - | - | - |
| **Ponds overpopulated with other species[1]** | | | | | |
| 31 | - | - | 1,249 (14) | [3]354 (99) | Madtoms. |
| 19 | * | 355 (6) | 144 (4) | [4]216 (16) | Orange-spotted sunfish. |
| 7 | - | 72 (14) | 42 (21) | [4]17 (18)<br>[5]28 (18) | - |
| 32 | - | - | 435 (7) | [6]588 (12) | - |
| 20 | - | - | 769 (15) | - | - |

[1]According to the Swingle method of population analysis.
[2]The asterisk indicates that not enough fish were taken for an estimate.
[3]Green sunfish.
[4]Crappie.
[5]Golden shiner.
[6]Goldfish.

of equipment was used again for sampling. Each haul was again recorded separately to indicate the marked and unmarked of each species. The number of hauls taken this time varied from 2 to 5.

A population estimate based on the marking and recapture method could not be made on 13 of the ponds checked with the Swingle method of population analysis. Six of these ponds had such a growth of vegetation, particularly filamentous green algae and pondweeds, that the net either rolled into a rope or became so heavily loaded with algae that it was impossible to pull it and to obtain sufficient numbers of fish. Other ponds had submerged

trees and other debris which prevented proper seining.

In 19 ponds complete population estimates were made with varying degrees of success (table 3). Except where difficulty was encountered in capturing the largemouth bass with a seine, an estimate was obtained of the predominant species present. Several ponds contained species which were not numerous enough to justify a population estimate. The accuracy of the estimates varied with the species.

TABLE 3.--Pounds of fish per acre in each pond

[Species composition expressed as percentages of weight]

| Pond No. | Pounds per acre | Largemouth bass | Bluegill | Bullhead | Other species | Poundage ratio of carnivorous to forage fish |
|---|---|---|---|---|---|---|
| **Ponds with a balanced population[1]** | | | | | | |
| 36 | 70 | 16.4 | 18.6 | - | [2]65 | 1:5 |
| 33 | 131 | 26.3 | 73.7 | - | - | 1:3 |
| 18 | 65.5 | 15.3 | 84.7 | - | - | 1:6 |
| 17 | 220 | 17.2 | 82.8 | - | - | 1:5 |
| [3]16 | 76.5 | 0.9 | 44.1 | 46.9 | [2]4.1<br>[4]3.9 | 1:10 |
| [3]2 | 102.5 | 0.3 | 99.7 | - | - | 1:332 |
| **Ponds overpopulated with bluegill[1]** | | | | | | |
| 15 | 180 | 18.7 | 79.6 | - | [5]1.7 | 1:4 |
| 9 | 28 | 24.9 | 75.1 | - | - | 1:3 |
| [3]8 | 205 | - | 28.8 | 71.2 | - | - |
| 4 | 72.6 | - | 51.5 | 45.4 | [2]3 | - |
| [3]3 | 58.2 | 7 | 27.1 | 19.4 | [2]46.5 | 1:13 |
| 1 | 202 | 3.6 | 21.4 | 36 | [6]39.1 | 1:27 |
| **Ponds overpopulated with bass[1]** | | | | | | |
| 35 | 100 | 33.5 | 66.5 | - | - | 1:2 |
| 34 | 110 | 13.1 | 86.9 | - | - | 1:7 |
| **Ponds overpopulated with other species of fish[1]** | | | | | | |
| 31 | 288 | - | - | 81.9 | [2]9.9<br>[4]8.2 | 1:11 |
| [3]19 | 151 | 2 | 47.1 | 30.7 | [7]20.2 | 1:4 |
| 7 | 53.6 | - | 57.9 | 29.4 | [7]8.9<br>[5]3.7 | 1:10 |
| 32 | 370.2 | - | - | 34 | [5]66 | - |
| 20 | 134.3 | - | - | 100 | - | - |

[1]According to the Swingle method of population analysis.
[2]Green sunfish.
[3]Other fish present as indicated in table 3, but only a very minor number.
[4]Carnivorous--bass and crappie; Forage--bluegill, bullhead, green sunfish, goldfish, and golden shiner.
[5]Golden shiner.
[6]Goldfish.
[7]Crappie.

A species such as the bluegill, which is relatively easy to seine, generally can be estimated with a reasonably low standard error of estimate. The standard error of the estimate was very high for largemouth black bass in a majority of the ponds checked. In three of the ponds, indicated as being in balance, there were not enough bass captured to make an estimate. A reason for this--aside from the fact that bass are very difficult to seine because of their ability to go around the net--may be that the number of bass actually was low. These ponds were small, and the estimates of total poundage of bluegills in these three ponds ranged from 14 to 43. On a 1:5 ratio, this would mean only 3 to 9 pounds of bass in each of these ponds.

The size range of the fish covered in the estimates varied. At the beginning of the survey, some of the estimates included the 1- and 2-inch fish. This practice was abandoned in the latter part of the survey. It was decided that the error in estimating these smaller fishes was too great because the mortality due to handling was fairly high.

As the lengths of all fish handled during the population estimates were recorded, the percentage frequencies of the fish in each length class were determined for each species in each pond. From these length frequencies and computed length-weight relationships, the weights of the populations were estimated and converted to a pounds-per-acre basis (table 3). The amount of fish in pounds per acre was not so great as that found in some other waters, but it is probably fairly representative of ponds in the Midwest. The standing crop ranged from 28 to 370 pounds per acre and averaged 138 pounds.

Feeding habits of different fish have a wide variation. Some fish feed primarily on other fish and their own young, and the other extreme would be those that feed mainly upon the vegetation and bottom material. The bodies of water with a fish population largely of the forage type would maintain a higher total carrying capacity than a body of water with a predominance of carnivorous fish (Swingle and Smith 1941b). Among the noncarnivorous fishes there is also a difference in carrying capacity which might be due to the shorter food chain, as suggested by Thompson (1941).

The ponds classed as overpopulated with other species of fish appeared to have a higher poundage per acre than the other ponds. The shorter food cycle of some of the species may account for this difference. There seemed to be no difference in the standing crop of ponds in the other three classifications set up by the Swingle method. The ponds in balance had neither higher nor lower poundage of fish per acre than ponds overpopulated with largemouth bass or bluegills.

To indicate the relationship of different types of fish, each species of fish was classified as either carnivorous or forage. Black and white crappie and largemouth black bass were classified as carnivorous fish; bluegills, bullheads, green sunfish, golden shiner, and goldfish were classified as forage fish. Although the population estimates for the bass in some ponds are probably low because of difficulties in catching the largemouth bass for the estimate, the poundage ratios between carnivorous and forage fish are about as might be expected (table 3). In four of the six ponds classified as in balance, the ratio was near the 1:5 usually considered desirable. In only four other ponds were the ratios as close to 1:5. Two of these ponds (No. 9 and No. 15) had been classed as overcrowded with bluegills, one pond (No. 34) was overcrowded with largemouth bass, and one pond (No. 19) was overcrowded with other species. In No. 19, the crappie probably helped the bass maintain a population balance.

Swingle and Smith (1941a), in their work with the largemouth bass and bluegill combination, found that in a balanced condition the majority of the weight in the population was made up of desirable-sized largemouth bass and bluegills. From the length-frequency distribution of the fish in each pond, the percentage of the desirable-sized fish of each species was calculated (table 4). In the ponds with a balanced population most of the weight of each species was of the desirable size. The desirable-sized largemouth bass and bluegill constituted 94.3 percent of the population of one pond (No. 33) and 78.7

TABLE 4.--Percentages of total weight and number of the fish of desirable size[1/] in each pond

| Pond No. | Crappie | | Bass | | Bluegill | | Bullhead | |
|---|---|---|---|---|---|---|---|---|
| | Weight | Number | Weight | Number | Weight | Number | Weight | Number |
| **Ponds with a balanced population** | | | | | | | | |
| 36 | - | - | 100 | 100 | 14.4 | 1.0 | - | - |
| 33 | - | - | 91.4 | 17.3 | 95.3 | 20.8 | - | - |
| 18 | - | - | 58.4 | 60 | 55.7 | 14.4 | - | - |
| 17 | - | - | 0 | 0 | 95.6 | 84.6 | - | - |
| 16 | - | - | 0 | 0 | 85.9 | 27.7 | - | - |
| 2 | - | - | 0 | 0 | 14.3 | 1.3 | - | - |
| **Ponds overpopulated with bluegills** | | | | | | | | |
| 15 | - | - | 100 | 100 | 51.6 | 12.4 | - | - |
| 9 | - | - | 0 | 0 | 6.7 | 2.2 | - | - |
| 8 | - | - | - | - | 0 | 0 | 3.3 | 25 |
| 4 | - | - | - | - | 79.5 | 48.3 | 87.6 | 84.6 |
| 3 | - | - | 100 | 100 | 44.9 | 14.1 | 65.4 | 25 |
| 1 | - | - | 0 | 0 | 5.4 | 1 | 47.7 | 26.5 |
| **Ponds overpopulated with bass** | | | | | | | | |
| 35 | - | - | 0 | 0 | 53.9 | 14.3 | - | - |
| 34 | - | - | 0 | 0 | 91.4 | 44.1 | - | - |
| **Ponds overpopulated with other species** | | | | | | | | |
| 31 | 31.1 | 6.8 | - | - | - | - | 50.2 | 46 |
| 19 | 82 | 12 | 0 | 0 | 30 | 14.9 | 100 | 100 |
| 7 | 16 | 6.3 | - | - | 0 | 0 | 59.7 | 52 |
| 32 | - | - | - | - | - | - | 18.9 | 22.1 |
| 20 | - | - | - | - | - | - | 0 | 0 |

[1/] Black and white crappie--8 inches; largemouth bass--10 inches; bluegill--6 inches; bullhead--7 inches.

percent of another (No. 17). These percentages closely resemble those reported by Swingle and Smith (1941a) for balanced populations of bluegills and largemouth bass. Compared to these, the overpopulated ponds showed very low percentages of desirable-sized largemouth bass except in the bluegill overpopulation. When there is an overpopulation of bluegills, a few bass may be expected, but they will be large and with no intermediate sizes, as in No. 15 and No. 3. The bluegills, when overabundant, tended to be smaller; the desirable sizes were not so numerous as when ponds were balanced. When a pond was overpopulated with largemouth bass, the bass were of a relatively uniform size and not very large. There were no desirable-sized largemouth bass in the two ponds overpopulated with bass. The bluegills in these two ponds were not numerous but were of a desirable size. In ponds overpopulated with other species, the largemouth bass were absent or rare.

This survey gives some clues as to the importance of various management practices in the production of fish in farm stock ponds. Many of the ponds were very turbid and silted. The data indicate that this turbidity reduces the production. Every one of the seven ponds containing less than 100 pounds of fish per acre was badly

silted. Of the 12 ponds containing more than 100 pounds of fish per acre, 5 were badly silted. In three of the latter, bullheads formed a major part of the fish population.

Transparency of the water was greatest in the vegetated ponds. The vegetation seemed to settle the incoming colloidal clay much faster than occurred when no vegetation was present. It also impeded the action of the waves on the settled silt and on the erosion of the margin. Several of the ponds had too heavy a crop of vegetation to allow a complete population estimate. As the Swingle method was not handicapped in this respect, it was applied on these ponds. Of the nine ponds that were very heavily vegetated, especially with filamentous green algae, six were rated as being in a balanced condition; two, overpopulated with other species; and one, overpopulated with bluegills. This seems to indicate that the vegetation did not protect the small forage fish from the carnivorous fish to such an extent that the forage fish had become overabundant.

In the fertilized ponds there was a marked absence of the filamentous green algae except for a small trace along the margin in the shallow water where the plankton turbidity could not keep the sunlight from encouraging filamentous growth. In the absence of the filamentous algae, hook-and-line operations were much more successful in harvesting the fish.

In fertilized ponds with a balanced population, the fish appeared to grow more rapidly and were in better condition. Ponds No. 33 and No. 2 were stocked with largemouth bass and bluegills in 1945. Data obtained by Swingle's method of population analysis indicated that both ponds were in a balanced condition. In No. 33, which was fertilized, 95 percent of the bluegills and 91 percent of the bass (on a poundage basis) were of desirable size. In a pond (No. 2) which was not fertilized, none of the largemouth bass were of a desirable size and 14 percent of the total poundage of bluegills were of desirable size. Pond No. 33 has been producing some very good hook-and-line fishing for the last 2 years. It would be reasonable to assume that the 7- to 9.9-inch bluegills and the 11- to 11.9-inch largemouth bass in No. 33 were of the original stock and therefore 3-year-old fish. The bluegills of this pond were larger at 3 years than the 3-year-old bluegills in Lake Onized in Illinois (Bennett 1945).

The largemouth bass and bluegill combination has been recommended as the most desirable combination of species for stocking farm ponds, but other species are sometimes substituted. The data in table 3 indicate a greater chance of overpopulation when these other species are added. Most of the ponds classed as having a bluegill overpopulation contained other species. These results plus Anderson's report (1948) indicate that whenever possible species other than largemouth bass and bluegills should be excluded from the pond if the most desirable results are to be obtained over a period of years.

The rate at which largemouth bass and bluegills should be stocked has been a controversial issue for some time. The stocking ratio most widely recommended is approximately 100 largemouth and 1,000 bluegill fingerlings per acre in fertilized ponds. It could be expected that in the ponds stocked with more largemouth bass than the 1:10 ratio, the percentage becoming overpopulated with largemouth bass would be large (table 5). The one pond that had been stocked at a ratio of 1:1 was overcrowded with bass, but none of the others stocked at ratios up to 1:10 were overpopulated with largemouth bass. For the ponds stocked with more bluegills than the 1:10 ratio, the reasonable expectancy would be bluegill overpopulation. The pond stocked at a ratio of 1:25 gave the results that would be expected. The pond stocked at a ratio of 1:16 was in balance, and only 33 percent of those stocked at a ratio of 1:15 were overpopulated with bluegills. It would seem, therefore, that the effects of the difference in stocking ratios are masked by the many other factors which affect the population balance.

## SUMMARY

A survey of 33 Iowa ponds indicated

TABLE 5.--Condition of ponds as related to the stocking ratio

| Bass-bluegill ratio | Number of ponds | | | |
|---|---|---|---|---|
| | Overpopulated with bass | In balance | Overpopulated with bluegill | Overpopulated with other species |
| 1:1 | 1 | - | - | - |
| 1:3 | - | 2 | 1 | 2 |
| 1:6 | - | - | 2 | - |
| 1:7 | - | 1 | - | - |
| 1:10 | 2 | 3 | 1 | - |
| 1:13 | - | - | - | 1 |
| 1:15 | - | 2 | 1 | - |
| 1:16 | - | 1 | - | - |
| 1:25 | - | - | 1 | - |

that the fish populations were in a balanced condition in 45 percent of these ponds, that they were overcrowded with bluegills in 21 percent, with largemouth black bass in 10 percent, and with other species in 24 percent. Older ponds were more often overcrowded than recently stocked ponds. The standing crop of fish in the various ponds ranged from 28 to 370 pounds per acre and averaged 138 pounds per acre.

A comparison of the results of the Swingle method and the results of the marking and recovery method indicates a moderate amount of agreement in evaluating populations. The marking and recovery method cannot be used effectively in ponds that have quantities of aquatic plants, filamentous algae, or snags, unless some method more efficient than seining is used in collecting the fish. When made by the marking and recovery method, estimates of largemouth bass population tend to be rather inaccurate and probably too low because of difficulties in catching the bass.

The difficulty of separating with certainty young-of-the-year bluegills from the yearlings late in the summer may cause errors in the interpretation of population data obtained with the Swingle method. The presence of species other than bass and bluegills may also cause difficulty in using the Swingle method.

Some ponds contained no carnivorous fish; in other ponds the ratio of pounds of carnivorous fish to pounds of forage fish ranged to 1:2 or, as in balanced ponds, to about 1:5. The percentage of desirable-sized fish gives an indication of the condition of the fish population. Some ponds yielded no desirable-sized fish.

Turbid and silted ponds were less productive than the clearer ponds. Growth and condition of the fish were better in fertilized ponds. There was no evidence that vegetation encouraged overpopulation of forage fish.

For the best results over a period of years, only largemouth black bass and bluegills should be stocked. Overpopulation increases when other species are added. In determining the condition of the fish population in later years, the stocking ratio may not be so important as other factors in management. Balanced populations resulted from stocking ratios ranging from 1 bass to 3 bluegills to 1 bass to 16 bluegills. Ponds overpopulated with bluegills had been stocked in the same ratios.

## ACKNOWLEDGMENTS

The author wishes to thank Dr. Kenneth D. Carlander for his guidance and assistance in conducting the investigation. Appreciation for suggestions and advice is also due Mr. Wallace L. Anderson, Chief, Regional Biology Division, U. S. Soil Conservation Service. The author is also grateful to Mr. Reynold A. Fredin and Mrs. Carlander for their assistance in collecting and tabulating the field data. Mr. Fredin also assisted with some of the statistical analysis.

The work could not have been accomplished without the cooperation of many

U. S. Soil Conservation Service and Iowa State Conservation Commission employees and of the farmers on whose land the ponds were located.

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Yields of 450 to 4,000 pounds of fish per acre per year have been reported from fish farms in the Middle and Far East. Chanos, Tilapia, mullet, and prawns have been among the best stock in various parts of Palestine, Egypt, China, and the East Indies. Most of the fish do not spawn in the ponds, so that it is necessary to supply fry. The feeds used include cut grass, oil cake, and manure.

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The rainfall of fish reported in October 1947 at Marksville, Louisiana, included largemouth black bass (Micropterus salmoides), goggle-eye (Chaenobryttus coronarius), two species of sunfish (Lepomis), several species of minnows, and hickory shad (Pomolobus mediocris)--all native to local waters.

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## BLUEBACKS FROM THE WINTHROP STATION

The holding ponds of the U. S. Fish-Cultural Station at Winthrop, Washington, contained approximately 1,300 blueback salmon early in October 1949. The run of bluebacks over Rock Island Dam was estimated at 18,000. Apparently, therefore, 1 of almost every 14 bluebacks returned to the Winthrop holding ponds--or approximately 7 percent of the bluebacks passing over Rock Island Dam were the direct result of blueback releases from the Winthrop station. This return of bluebacks to the Methow River (which, prior to these hatchery releases, never had any bluebacks) is an excellent indication of the success of the hatchery operations. Incidentally, the north fork of the Methow River was not racked, and some of the bluebacks which ascended the Methow may have gone up that fork.

The return of bluebacks to the Winthrop station has been on the increase. The release of fingerlings, however, has always been less than 100,000 except during the flood of 1948, when all but the marked fish were freed by flood waters.

The bluebacks in the holding ponds at Winthrop are considerably larger than the average blueback seen on the lower river or at Lake Wenatchee. It has been suggested that the fish released from the Winthrop station may have gone downstream to the ocean without delay, starting their ocean growth at an earlier age, whereas bluebacks released into the lake may have remained there for some time before migrating downstream.

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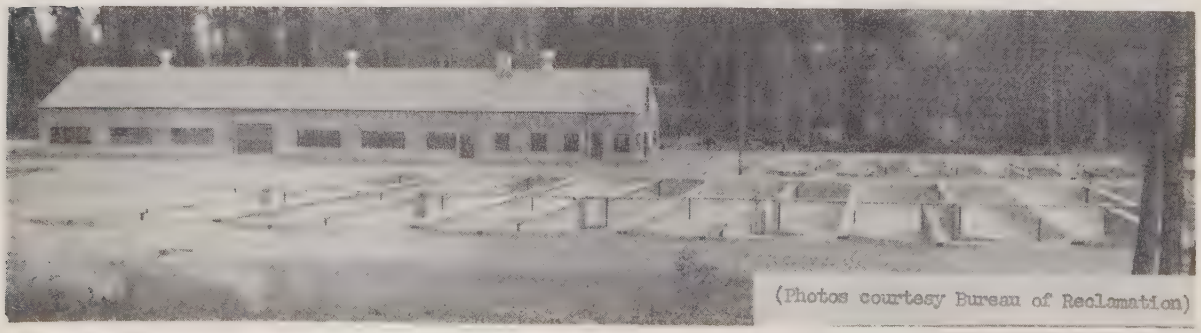

(Photos courtesy Bureau of Reclamation)

# PROPAGATION OF FRESH-WATER MUSSELS

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IN 1695, Leeuwenhoek, the Dutch microscopist, studied the anatomy and reproductive processes of fresh-water mussels. He learned that the eggs pass from the ovaries to the gill passages, where embryonic development is completed. His work was lost to science for about a hundred and fifty years, however, and the general belief was that the organisms found in a mussel's gills were parasites preying upon the mussel. The organisms were given the name, Glochidium parasiticum.

Carus, in 1832, concluded that these tiny living bivalves were the larvae of the adult mussel which bore them, but he was unable to bring about continued development after they were separated from the parent mussel.

It was not until 1866 that Leydig discovered that the larval mussels became parasites on fishes and that parasitism was essential to their development. Little was known of their life history or ecology until a considerably later date. The discovery in the latter years of the nineteenth century that the shells of fresh-water mussels could be used in the manufacture of buttons led to the invention and improvement of cutting and finishing machines and the opening of mussel fisheries in the upper Mississippi River and its tributaries.

Intensive harvesting of mussels in these streams caused fear that a valuable natural resource would be depleted, and in 1894 the United States Bureau of Fisheries became actively interested in gaining knowledge of mussels and in developing means of artificially propagating them in order to insure a continued supply to meet commercial demands.

A biological station was built at Fairport, Iowa, on the Mississippi River, for the primary purpose of studying mussels and developing methods of propagating them.

Prior to 1910, George Lefevre and Winterton C. Curtis worked there intensively on reproduction and artificial propagation. Their studies were continued at the University of Missouri. Much of their work was of a pioneer nature.

Dr. Robert E. Coker, who was in charge of the Fairport Biological Station for some time, made extensive studies of mussel populations and advocated conservation measures for the protection of mussels. Dr. Coker, with the collaboration of Dr. A. F. Shira, Dr. H. W. Clark, and Dr. A. D. Howard, made intensive studies of the natural history of fresh-water mussels and of methods of propagation.

By the efforts of workers at the Fairport Station, many attempts were made to rear mussels in ponds and troughs and in enclosures in the river.

Propagation was undertaken successfully by means of artificially infecting the gills of fish with glochidia. Most of this work was conducted in the Lake Pepin area of the Mississippi River. Experimental work led to the determination of the species of fishes required as hosts to the various species of mussels and provided more accurate knowledge of the life history and ecology of mussels.

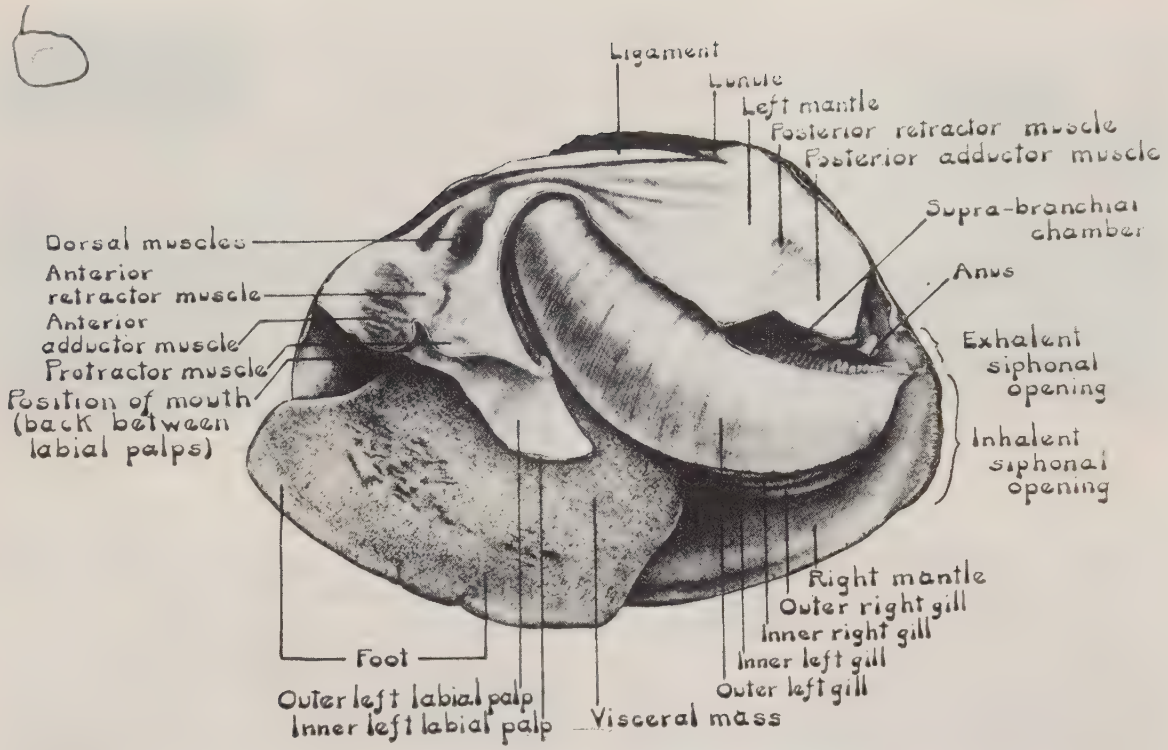



FIG. 1.—The structure of a fresh-water mussel. (Based upon drawing of white heel-splitter, *Symphynota complanata*, from Lefevre and Curtis, 1912.)

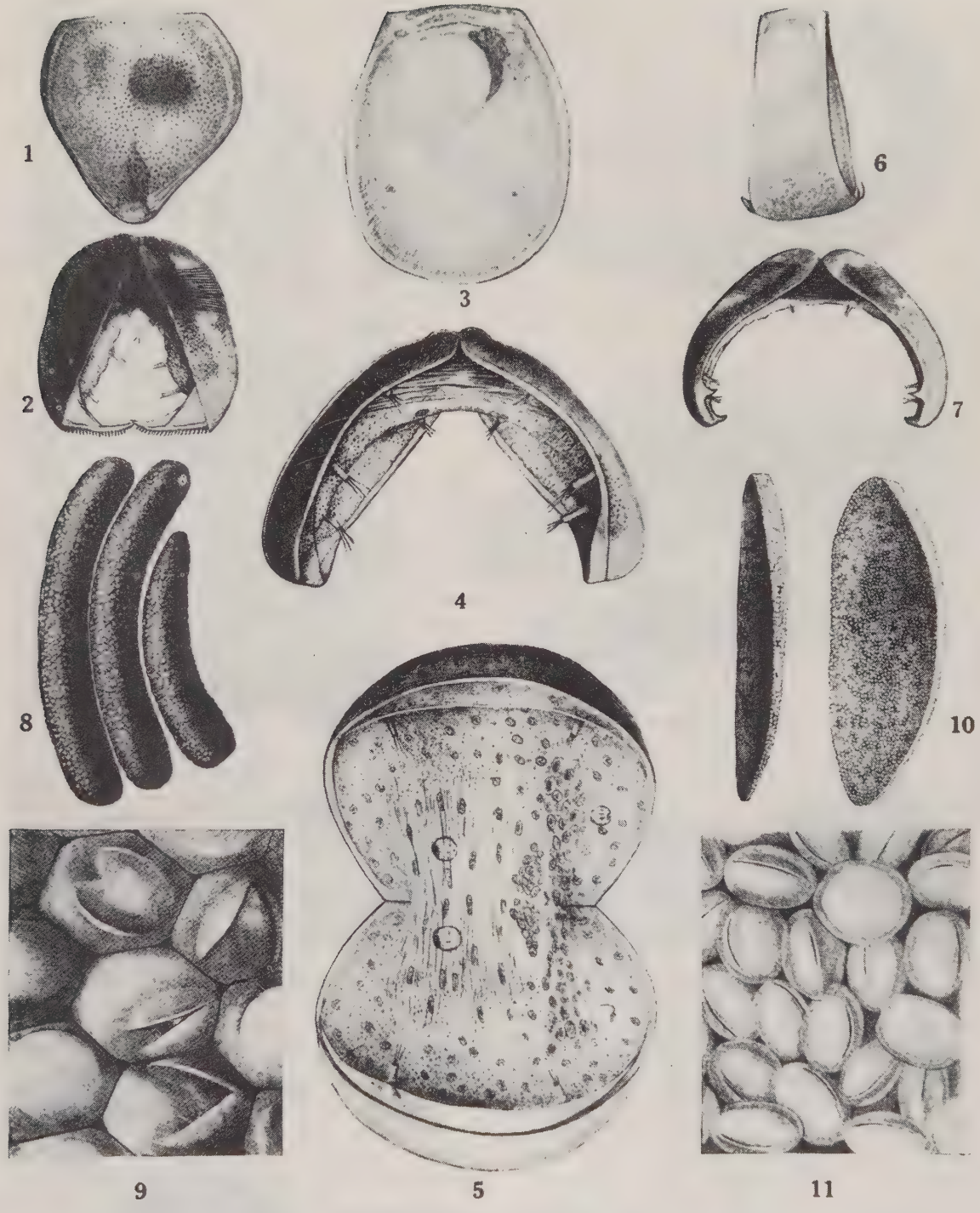
The efforts of these workers gave us the first complete picture of the life history of fresh-water mussels.

## LIFE HISTORY

In the so-called long-term or winter breeders, fertilization takes place in late July and August. This group of breeders includes yellow sand-shells and muckets. Embryonic development occurs within a few weeks, and the young mussels are carried as mature glochidia until the following spring or early summer, when the gravid females move into shoal water and spawning occurs. The eggs of short-term or summer breeders are fertilized early in spring, and spawning takes place in the fall. This latter group includes pig-toes, niggerheads, pimple-backs, and butterflies.

Sexes are separate, and spermatozoa are drawn from the male mussel through the incurrent siphon of the female to fertilize the eggs. Some investigators believe that actual fertilization takes place while the eggs are migrating from the ovaries to the gills, which swell to accommodate an estimated 2 million eggs. Each gill chamber holds a mass of eggs in a jellylike matrix called a conglutinate. As embryonic development progresses, the eggs become separate in the brood pouch and shell membranes disappear. At the end of this embryonic phase, the larval mussel is a minute bivalve, 0.4 to 0.5 millimeter in longest dimension, possessing a thin tissue of mantle on the inner surface, a cross band of muscle tissue between the valves, and fine hairlike projections believed to be tactile in function. Germ plasm is, of course, present in the living tissue. In this latter phase the larvae are referred to as glochidia.

In natural reproduction the glochidia are dispersed into the water through the excurrent siphon of the parent mussel and are carried in suspension by water currents. As the water bearing them passes through the gill chamber of a fish,




[Figures from Lefevre and Curtis, 1912.]

FIGS. 1 and 2.—Hooked glochidium of *Symphynota costata*.

FIGS. 3, 4, and 5.—Hookless glochidium of *Lampsilis subrostrata*.

FIGS. 6 and 7.—Ax-head glochidium of *Lampsilis* (*Proptera*) *alata*.

FIG. 8.—Conglutinates (masses of glochidia) from the three-horned warty back, *Obliquaria reflexa*.

FIG. 9. Portion of conglutinate of *Obliquaria reflexa*, magnified. Glochidia still within egg membranes which are closely pressed and adhering together.

FIG. 10.—Conglutinates (masses of glochidia) from the mucket, *Lampsilis luteola*.

FIG. 11.—Portion of conglutinate of *Lampsilis luteola*, magnified. Glochidia inclosed in membranes are embedded in a mucilaginous matrix.

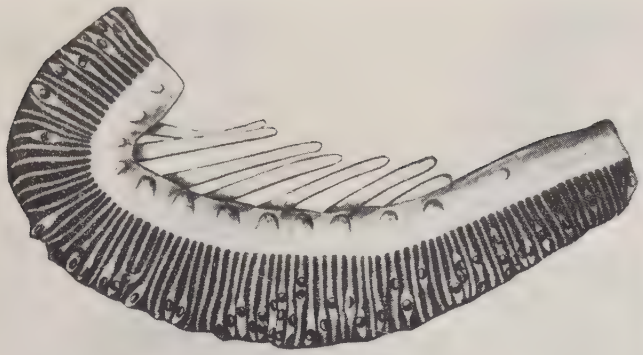


FIG. 1.—Gill of a black bass infected with glochidia of mucket, *Lampsilis ligamentina*.

FIG. 3.—Three gill filaments of rock bass, with glochidia of mucket.

FIG. 2.—Part of fig. 1, enlarged.

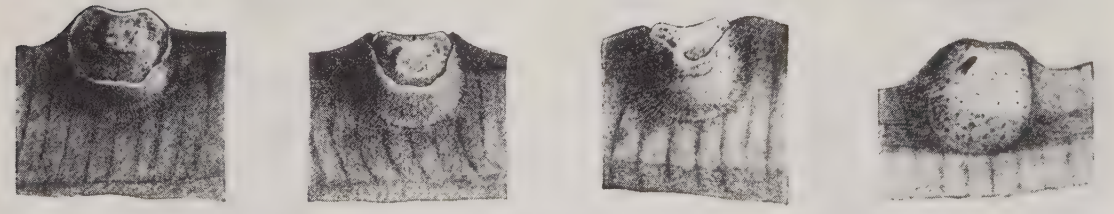


FIG. 4.—Stages in formation of cyst surrounding a glochidium of the mucket. Taken at 15 minutes, 30 minutes, 1 hour, and 3 hours, respectively, after infection.

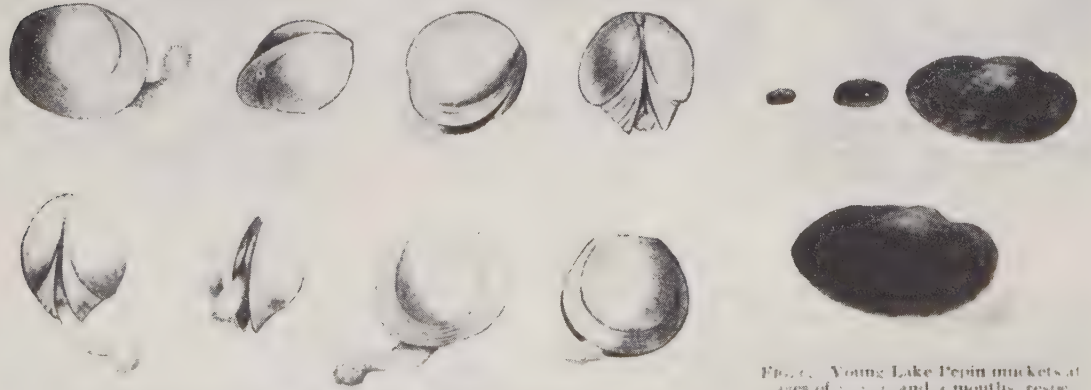


FIG. [illegible] Young mussels, one week after liberation from the fish, showing new growth of shell, cilia on foot, and positions assumed in crawling. Enlarged.

FIG. [illegible] Young Lake Pepin mussels at ages of [illegible], and 4 months, respectively. Natural size.

[Figs. 1-5 after Lefevre and Curtis]

the glochidia attach themselves to the fish's gill by closing on the tissue. A cyst is formed by the proliferation of cells from the fish's gill. The formation of this protective cyst begins almost at once, and the glochidium is usually completely enclosed within 24 hours. The attachment to the tissue of the fish marks the beginning of the parasitic phase. Glochidia are nourished through this phase by the blood of the fish. They do not increase in size but develop parts similar to those of an adult mussel. The time they remain on the fish is governed by the water temperature and varies from 10 to 30 days in summer conditions. It may last until the following spring if the attachment takes place late in the fall.

At the end of the parasitic phase, the glochidium is equipped with a protractile foot. This larval foot has a hardened terminal portion. Movement of the foot effects the release of the glochidium from its cyst. Chemical change may aid in the break-down of the cyst.

After release from the host fish, the glochidium falls to the bottom. A byssus gland secretes a long sticky strand which is quite strong and may serve as an anchor on swift rocky bottoms. Young mussels from the end of the parasitic phase until they reach a length of 20 millimeters are referred to as juvenile mussels.

## FORMER METHODS OF PROPAGATION

In 1930, Dr. M. M. Ellis of the U. S. Bureau of Fisheries announced that it was possible, by laboratory methods and the use of nutrient solution, to bring young mussels from the glochidial to the juvenile stage without the use of a host fish. This method, although successful in the laboratory, did not prove to be practical for handling the large quantities of glochidia needed in a rehabilitation program.

As a result of early experiments at the Fairport Station and in the interest of economy, the Bureau of Fisheries inaugurated a program of mussel planting in which the fish-rescue crews regularly employed on the upper Mississippi during the summer infected the rescued fish with glochidia before releasing the fish into the parent stream. The fish crews obtained gravid female mussels of the desired species, either from the stream where rescued fish were being liberated or from selected locations where more desirable specimens were available. In the latter instance, the gravid mussels were packed in ice and shipped to the site of operations, where, after tempering, they were held in running water until needed. Gravid mussels were carried by fish crews in pails or tubs of water and used as required. Host fish were placed in a tub containing a small amount of river water. Glochidia were then added to the water by opening one or two gravid mussels and pressing out the glochidial masses. After waiting a few minutes for the glochidia to become fixed, the workers emptied the tub into the stream and then repeated the process as necessary. This fish-infection program was carried on until 1930. By that time, the changes in habitat caused by silting and pollution had seriously diminished the mussel-producing potential of the upper Mississippi River and many of its tributaries.

Conversations with commercial users who had knowledge of this work and who were familiar with the yearly harvest of commercial mussels, disclosed the prevailing opinion that increased mussel production was evident in the areas where such infection work had been done.

Although the method used produced results in Lake Pepin and other areas, and although it was performed economically by combining fish infection with fish rescue work, later investigation and testing of the method showed that infection thus obtained gave inconstant results as to the numbers of glochidia fixed on the fish's gills. (Unpublished reports, Ellis, Westfall, and others.) Further experiments demonstrated that the excitation of the fish during seining and handling and the anoxia caused by crowding in tubs accelerated liberation of carbon dioxide and kidney wastes into the water, and that these substances reached concentration levels which caused premature closing of glochidia. Mucous secretion from gills and body surface greatly increases when fish are excited. This is particularly true of gar. Strands of

mucus from excited fish in the tub entangled particles of debris, forming slime strings which, in turn, enmeshed glochidia and thus contributed to the conditions which tended to prevent successful attachment of glochidia. Thick coatings of mucus on the gills interfered with closing action of glochidia to such extent that many were sloughed off within 24 hours after attachment.

As these conditions became apparent, a method of fish infection was developed in which the objectionable factors could be controlled or eliminated (Ellis, Westfall, and Ellis, unpublished report). This method was tested and proved successful by Dr. B. A. Westfall on the White and St. Francis Rivers in Arkansas. In 1936 plantings were made with gar confined in enclosures. When the areas were examined in 1937 and 1938, thick beds of juvenile sand-shells were found. Similar success was achieved with plantings of muckets in Illinois. The same method was used in intensive plantings in Arkansas and Indiana during the summer of 1941. Comparison of tonnage purchased from the planted areas in 1945 with the tonnage of 1941 showed a marked increase.

This method is referred to as the modified artificial infection method and is employed in the present mussel planting program.

## MODIFIED ARTIFICIAL INFECTION METHOD

### Selection of Glochidia

Only fresh glochidia are used, and the infection is made as soon as possible after gravid mussels are collected. Gravid female mussels are selected by examining freshly caught mussels. Preliminary examination is made by inserting a thin-edged "clam opener" between the valves at the ventral edge and prying the valves apart only enough to see into the interior. The modified gills, or marsupia, are quite plump in the "ripe" mussel. If all gills are flat, the specimen is either a male or a very "green" female. Different numbers and/or portions of the gills may serve as brood pouches. In the sand-shell the outer gill of each pair carries the glochidia. In the ripe yellow sand-shell the gill is full and rounded along its entire length and has black beading on the distal edge.

Males and females of some species of mussels may be distinguished by differences in the contour of the shells. The female yellow sand-shell has a swelling near the posterior which gives the ventral line of the shell a slightly emarginate appearance. This swelling coincides with the position of the modified or marsupial gills.

When a number of gravid mussels have been found and segregated, they are placed in flowing stream water to be convenient for use. The final selection is then made by taking a sample of glochidia from each mussel. The valves are pried apart only far enough to admit the end of a pipette. Caution is used in opening, as the mussel, if not yet ready, may be returned to the stream for later use, and adductor muscles torn by too much stretching will cause the mussel to die. After the valves are slightly separated, a small wooden wedge is placed between them to hold them apart. The point of a sharp scalpel is then inserted between the valves to make a slit at the end of one marsupial chamber. A bulb pipette with a small amount of water at the tip is then touched to the slit in the gill. Water is forced from the pipette. If the glochidia are free from the agglutination, they will be carried out with the drop of water and may then be drawn into the pipette. The pipette is held vertically until the glochidia have settled to the tip. They are then placed on a watch glass or slide and examined under a low-powered lens or microscope. Healthy glochidia which are ready for parasitism will be in a gaping position. The valves may usually be seen to move slightly in and out; they occasionally snap together but immediately open. Under higher magnification the valves have a pearly, slightly granular appearance when they are fully mature. Sometimes a marsupium may have the appearance of containing fully matured glochidia. Examination will show them to be still within the egg membrane. Fully matured glochidia always separate easily and are readily removed from the chambers. Often they will burst forth from the stretched marsupium when it is touched

Sorting mussels from holding cage. The gar will serve as host fish.

Indicating location of glochidia in ripe mussel.

Washing glochidia.

Tanks (see text) used while inoculating host fish with glochidia.

by the point of a scalpel. If the valves of the glochidia are opened wide, i.e., flattened to 180°, they are dead. This is the condition found when bacterial or protozoan parasites have consumed the living tissue.

The means used to determine the suitability of glochidia for use in infection is to test the closing time. A number of glochidia are placed in a drop of water under a low-powered microscope. A drop of 0.5-percent NaCl is introduced into the drop and its effect observed. The salt solution should cause the closing reaction. The closing of about 80 percent of the glochidia in a period of 60 seconds is considered good. Observation has shown that glochidia reach the optimum of closing response when they have been removed from the brood pouch and held in fresh water for about 30 minutes.

## Washing Glochidia

Washing in a flow of filtered stream water has been shown to be effective in cleaning glochidia and selecting by relative density those that are living and free of infection.

Further tests will be made to demonstrate the efficacy of the washing procedure. The present method makes use of the flow of filtered stream water siphoned through a rubber tube with screw clamp to control flow rate. Water is placed in a beaker of fairly large size (500 to 800 cubic centimeters), and glochidia from several mussels (previously tested and approved) are put into the water. The siphon hose is introduced into the beaker with the opening near the bottom and at an angle which will cause centrifugation. Flow is regulated so that the glochidia are kept in motion and the lighter ones are carried away as the beaker overflows. Dead glochidia are readily removed in this way. This season a settling-out process is to be tried as a method of selecting the more desirable glochidia.

Washing the glochidia is not imperative to obtaining fairly heavy infections, but it is believed that a higher percent of survival may be obtained by washing.

## Transportation of Gravid Mussels

Gravid mussels should be transported only when it is impossible to obtain desirable specimens near the site of operations.

Short trips are possible with mussels placed in pails or tubs of water when the temperature can be kept reasonably low and the time involved is not more than 2 to 3 hours. Express shipments have been made successfully when mussels were placed in pails and interspersed with cracked ice. The writer has found that when such shipments were made over long periods, the mortality following shipment was high.

Our present practice when required transportation involves a relatively long time, is to use auto ice-boxes in which bottom drains have been drilled. When transported by this method, each mussel is individually wrapped in cheesecloth. The cheesecloth is cut into pieces about 10 by 18 inches. Each shell is then wrapped in several layers of cloth, each piece being stretched tightly at right angles to the ventral or opening edge so as to make sure that the valves are tightly closed. Layers of wrapped shells are alternated with layers of cracked ice in the ice-box. If the trip is long, it may be necessary to renew the ice occasionally. Keeping mussels alive and in good condition by this method requires two things: (1) shells must not be allowed to open; (2) water from melting ice must not be allowed to accumulate to such extent as to immerse the mussels. In either case, high mortality results. The writer has not studied the physiology of this, but the supposition may be that when the mussel opens in the absence of water, non-replaced body fluids are lost and death ensues. When water immerses the mussel, it may be possible for the mussel to resume respiratory activity and subsequently death results from anoxia. It has been demonstrated that mussels exposed to air but having the valves closely bound together so that no living tissue is exposed, will remain alive for long periods. An adequate buffering system, probably drawing on carbondate from the shell, will maintain blood pH at the normal level

until just an hour or two before death. The survival time of mussels forced to remain closed has in some instances been as much as 30 days. High temperatures, naturally, will decrease the survival time.

The handling of brood mussels should be kept at a minimum. Prolonged storage in confinement and repeated handling often bring on abortion. Summer breeding mussels are more likely to abort than winter breeders.

## Handling of Host Fish

Host fish are used as soon as possible after capture. The earliest seining is done near the site of operation. Fish are held in a temporary pen made by staking out a live net made of seine webbing if they are to be held only a short time or of hardware cloth if they are too numerous or must be held overnight. Gar (Lepisosteus osseus or platostomus) are hosts to the yellow sand-shell, the species most frequently planted at present. Gar are not so tenacious of life as is generally supposed, and great care must be used in order to prevent mortality among infected fish. Experience has shown that in holding gar overnight (which should be done only when daylight fishing will not meet the need) mesh or web too small for bills to penetrate should be used, and that an area of moderate current should be chosen. Heavy losses may occur either in swift water or in static water--in the latter particularly if the fish are crowded. Gar are surprisingly sensitive to bruising. Rolling in the seine should be avoided, and the number of times the fish are handled should be kept at a minimum. Repeated handlings cause bleeding between scales; and our experience has been that when this bleeding occurs, the fish almost invariably die within 2 weeks. All species should, of course, be handled with care.

## Equipment and Procedure

Four metal tanks are arranged near the river. In hot weather shade is essential to prevent increase of the temperature of static water in tanks. If trees are not conveniently located, a canvas fly may be used. The tanks are painted with asphaltum varnish. They are 18 inches wide, 22 inches deep, and 54 inches long. Each tank has a threaded drain opening very near the bottom in one end, and a nipple and faucet may be screwed into the opening so that the outflow can be controlled. The four tanks are placed parallel to each other with the drain ends toward the river, and there is sufficient space so that operators may walk between the tanks.

A portable gasoline motor and pump unit with fittings adapted to 3/4-inch garden hose is used to supply running water for the first tank. The intake end of the hose is screened against debris and placed well below the surface and upstream from the zone of activity. The delivery end of the hose is covered with several thicknesses of cheesecloth to filter out suspended matter. The outlet faucet is adjusted to balance the inflow and maintain a constant level about 10 inches below the rim of the tank.

The second tank is used for gill disinfection and is filled with filtered water to a marked level which will give a known volume. An amount of neutral acriflavine which will give a solution of 1 part per million is added. The number of cubic inches of water divided by 61 gives the number of milligrams to be used to make a solution of 1 part per million. As this solution must be renewed after every four or five lots of fish, it is impractical to make analytical weights for each batch of solution. Standard No. 3 gelatine capsules are filled with acriflavine powder. A capsule is filled by holding the lower (inside) portion with a forceps and dipping into a beaker of the powder. The powder is slightly compressed and leveled by pressing the open end against the side of the beaker, and the cap is then put in place. Dosage is standardized by weighing five of the filled capsules, averaging their weights, and subtracting the average weight of five empty capsules which have been dried in a desiccator. This weight may then be used in calculating the level to calibrate the tank in order to obtain a solution of 1 part per million. Capsules are thereafter filled in the same manner without further analytical weighing. This

## COMMERCIAL MUSSELS AND THEIR HOSTS

[Table from Coker, Shira, Clark and Howard]

| Mussels | | Hosts | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Scientific name | Common name | A. melas, bullhead | A. nebulosus, bullhead | A. calvus, bowfin | A. chrysops, eel | A. grunniens, sheepshead | D. cepedianum, gizzard shad | E. lucius, pike | E. gibbosus, red-ear sunfish | H. tergisus, mooneye | I. punctatus, spotted cat | L. osseus, long-nosed gar | L. platostomus, short-nosed gar | L. tristoechus, alligator gar | L. cyanellus, blue-spotted sunfish | L. auryorus, sunfish | L. humilis, orange-spotted sunfish | L. pallidus, bluegill | L. olivaris, yellow cat | M. dolomieu, smallmouth black bass | M. salmoides, largemouth black bass | N. maculosus, mud puppy | P. chrysocloris, river herring | P. flavescens, yellow perch | P. annularis, white crappie | P. sparoides, black crappie | R. chrysops, striped bass | S. platorhynchus, sand sturgeon | S. gyrinus, madtom | S. canadense, sauger | S. vitreum, walleye |
| Lampsilis anodontoides | Yellow sand-shell | o | o | a | - | o | - | - | - | - | o | AN | A | A | no | - | n | o | - | - | na | - | - | o | no | no | a | o | - | o | - |
| Lampsilis fallaciosa | Slough sand-shell | - | - | - | - | - | - | - | - | - | o | - | NA | - | - | o | - | - | o | - | o | - | - | - | n | o | - | n | - | - | - |
| Lampsilis higginsii | Higgin's eye | - | - | - | - | n | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | N | - |
| Lampsilis ligamentina | Mucket | o | o | o | n | o | - | a | - | - | o | - | a | - | N | - | - | aN | - | N | AN | - | - | AN | NA | A | AN | o | n | A | - |
| Lampsilis luteola | Fat mucket | o | o | - | - | o | - | - | - | o | o | - | o | - | - | - | - | NA | o | A | A | - | - | AN | A | A | A | o | n | A | NA |
| Lampsilis recta | Black sand-shell | - | - | - | n | - | - | - | - | - | o | - | - | - | a | - | - | aN | - | - | - | - | - | - | N | - | - | - | - | - | - |
| Lampsilis ventricosa | Pocketbook | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | A | - | A | A | - | - | A | AN | - | - | - | - | N | - |
| Obovaria ellipsis | Missouri niggerhead | - | - | - | - | o | - | - | - | - | o | - | - | - | - | - | - | o | - | - | o | - | - | o | o | o | - | NA | - | - | - |
| Plagiola securis | Butterfly | - | - | - | - | NA | - | - | - | - | - | - | - | - | n | - | - | o | - | - | o | - | - | - | o | o | - | - | - | - | - |
| Quadrula ebenus | Niggerhead | o | o | o | - | o | a | - | - | o | o | - | - | - | o | - | - | o | o | - | o | - | TN | o | o | o | - | o | - | - | - |
| Quadrula heros | Washboard | A | A | - | N | Af Nf | Nf | - | - | - | Af | - | - | - | A | - | - | NA | AN | - | o | n | n | - | NA | A | N | - | Nf | - | - |
| Quadrula metanevra | Monkey-face | - | - | - | - | - | - | - | - | - | - | - | - | - | N | - | - | on | - | - | o | - | - | - | - | - | - | - | - | N | - |
| Quadrula plicata | Blue-point | a | a | - | - | - | - | N | N | - | o | - | A | - | - | A | - | a | o | - | AN | - | - | A | Nf AN | A | n | - | - | N | - |
| Quadrula pustulata | Warty-back | - | - | - | - | - | - | - | - | - | N | - | - | - | - | - | - | - | n | - | - | - | - | - | n | - | - | - | - | - | - |
| Quadrula pustulosa | do. | NA | A | - | - | - | - | - | - | - | AN | - | o | - | - | - | - | o | an | - | o | - | - | - | on | o | - | n | - | - | - |
| Quadrula solida | do. | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | N | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Quadrula undata | Pig-toe | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | n | n | - | - | - | - | - |

Explanation of table:

- N -- Found on the gills in natural infection.
- Nf -- Found on the fins in natural infection.
- n -- Record of natural infection but of doubtful significance.
- A -- Carried through on gills after artificial infection.
- Af -- Carried through on fins after artificial infection.
- a -- Results of artificial infection unsatisfactory or not uniform.
- o -- Tested and found unsuitable.
- T -- Tested; development occurred; host perhaps suitable, but experiment not carried to conclusion.

method is sufficiently accurate, as some variation in the strength of the solution is permissible, but solutions should never contain less than 0.75 or more than 2 parts per million. When a new stock of acriflavine is obtained, new average weights should be taken, as the fineness of the commercial powder may vary and cause an appreciable difference in the weight contained in each capsule. It is important that the acriflavine powder be kept dry at all times. When capsules are taken into the field, they are stored in small glass bottles.

The third tank is used only as a rinse to prevent the transfer of antiseptic solution to the infection tank. It is filled to a suitable level with filtered stream water and changed when the temperature rises or after 50 fish have been rinsed.

The fourth tank is used as the infection tank. Filtered water is used in a quantity commensurate with the size and number of fish to be infected, but this is always a relatively small amount. Better infections are obtained by thus concentrating the glochidia. This is particularly true of Centrarchids. The water in this tank should be watched carefully, and it should be discarded and renewed at once if it becomes warm or if mucous strings appear.

The procedure in handling the fish through the series of tanks is as follows:

Fish (a few at a time) are brought from the holding enclosures and put into the wash tank. They are given sufficient time in this tank to recover from excitement and for waste products and mucus to wash away. The usual time is from 15 to 30 minutes. After sufficient time in the wash tank the fish are transferred, one at a time, to the disinfecting tank. The transfer is made by hand and as gently and quickly as possible. Workers accustomed to handling fish can accomplish this with a minimum of disturbance. Small fish must be handled with a dip-net. As soon as all are transferred, another lot is placed in the wash tank.

The acriflavine solution cleans the gills of mucus. It also has a bacteriostatic effect and temporarily arrests the flow of mucus. The time required in this bath is from 5 to 15 minutes. The solution should be renewed after four or five lots of fish have been treated.

One or two minutes are sufficient in the rinse tank. After being rinsed, the fish are transferred to the infection tank, which has previously been charged with washed glochidia. Motion of the water caused by respiratory and swimming movements of the fish aids in keeping the glochidia suspended, but the occasional stirring of the water is advisable. Gills are examined at intervals to observe the progress of infection. Examination is facilitated by the use of a hand magnifying lens. Fifteen minutes will usually be sufficient for good infections. Infections are considered adequate when the glochidia are fixed thickly enough to appear as a white rim on the edges of the gills. Infections heavy enough to injure the fish are not likely with gar but may occasionally occur with Centrarchids. Each fish is examined. When satisfactory infections are apparent, the fish are placed in a separate holding pen for distribution.

Infected fish are carried in the tanks for distribution. They are carried by boat or truck to selected points for release. In the interest of returning fish to the stream in the best possible condition, fish are rarely carried more than 10 miles from the site of infection.

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More than forty million fish from hatcheries of the U. S. Fish and Wildlife Service were stocked in 16,455 farm ponds during 1948. The Federal Government places no restrictions on fishing the farm ponds so stocked, but the farmers must observe State laws in regard to licensing and the opening of their ponds to the public.

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There are only two occasions in American life when people have a regard for one's privacy. One is when you are at prayer; the other when you go fishing. At both, you are able to be by yourself.

--Herbert Hoover.

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# *a good keeper --*

... A good keeper is a good thing, and if he has a sharp dog, not too big, though, but who knows when to bark and when to hold his tongue, and who will even go in at a poacher and worry his trousers, if need be, he is a better. On a darkish night a dog will detect poachers when a keeper on his rounds could not. A bad keeper is about the worst thing that can happen to a water; none at all is infinitely preferable. A bad keeper may be bad from being only a fool, though a fool is very often a knave as well; or he may be careless, and prefer his bed to that of the river; or he may be partial to beer and tobacco, and fond of the public-house; and he may be an out-and-out drunken beast and idiot, who is at the mercy of every poacher who will stand him drinks; or he may be a perfected and sublimated scoundrel. There are a variety of badnesses. A good keeper should see as little of the public-house as need be. I do not say he never should go into one, or never have a pint of beer in one, though I did know a friend once who allowed his keepers a nine-gallon cask of beer once a fortnight in their own houses, and sacked them ruthlessly if he ever knew of their being in a public-house. A sharp keeper, who has his wits about him, can pick up a good deal at the pub. A peep into the tap of an evening will often tell him a good deal, and a pint of beer in good fellowship will make him popular, but he should never sit down for a booze. But an out-and-out bad keeper is a scoundrel of the worst type. He is ten times worse than the poacher himself; for he has a living assured him if he does his duty only tolerably; of course, the better he does his duty, the better that living will be sure to be, so there is no possible excuse for him. A rascal of this sort always has fifty thousand excuses cut and dried. If the poachers have had a success on the water below, "he had but a just left that werry water, and was gone up above;" and if above, "It were most unkimmon strange how they could, for he hadn't long left there for the water below." If they sweep the shallow, and you show him half a dozen places where the net has visibly been landed, with all the refuse, weeds, small fry, foot-marks, &c.--"Well, that be wonderful; whenever could they a done it? It must a bin when he thort he'd a heer'd or seed someun up on the deep water," and he grins quietly at your credulity as he feels the two or three half-crowns in his pocket, the proceeds of his share in the night's robbery. Then he cuts the weeds close on the shallows, where they can be netted easily, and leaves them long in the deeps, where they can't, in order to be able to say that there are plenty of weeds in the river. If you tell him to stake a shallow, he puts all the stakes where they are not wanted, and takes good care to put none at all where they are. He notes well where the best fish lie, and shuts the hatch down so as to draw all the fish up, and not to have too heavy a stream for the net. In fact, his devices to serve his friends the poachers, and to get from them the price of gallons of beer, are endless. Ostensibly he is the most civil, blarneying, carneying blackguard going, and butter won't melt in his mouth; and, oddly enough, there is not a man whom he meets when with you in the fields, but will "like to drink your honour's health." He puts them on to cadge on you, and stands in. I have, unfortunately, seen such keepers as this, though, thanks be, they are rare; and it is rather surprising that keepers, as a class, are as good as they are, as they are seldom overpaid for the duties they perform.

--Francis Francis, "The practical management of fisheries: a book for proprietors and keepers." London, 1883.

# COMPARISON OF THE NUMBER OF ERYTHROCYTES IN THE BLOOD OF HATCHERY-REARED AND WILD SILVER SALMON FINGERLINGS

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and
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Marsh (1902) and Marsh and Gorham (1906), commenting unenthusiastically upon the status of hatchery science, dourly pointed out that the number of erythrocytes and the hemoglobin content of the blood were greater in wild rainbow and brook trout than in domesticated fish of the same species. Apparently hatchery techniques have improved substantially in the intervening years. Recent observations of the blood of some hatchery-bred silver salmon (Oncorhynchus kisutch) fingerlings indicated that their erythrocyte counts compared most favorably with those of some wild stock.

These observations were made as part of a fundamental study of the hematology of the silver salmon, a study conducted at the School of Fisheries, University of Washington. These observations are published because they may be of interest to fish-culturists who seek to compare their charges with stocks of wild fish.

The wild salmon fingerlings were the offspring of the silver salmon spawning in Swamp Creek, near Seattle, Washington. The domesticated fingerlings were from the Washington State Department of Fisheries hatchery at Soos Creek, near Auburn, Washington. After the fish were procured from either source they were taken to the laboratory, where blood counts were made immediately. Comparatively little error could have been introduced during the transport of the wild fish from Swamp Creek, as this stream is only a few minutes from the laboratory. Soos Creek, on the other hand, is an hour's drive from the laboratory. During the travel involved, the agitation of the fish and the slight rise in water temperature may have caused some increase in the oxygen consumption and a consequent hemopoietic response, resulting possibly in slightly higher than normal erythrocyte counts.

All the fish arrived at the laboratory in excellent condition, and it is felt that the slight possible error introduced did not invalidate the conclusion, namely, that there was very little difference in the blood counts of the wild and hatchery fingerlings. Seven wild fingerlings that were collected in Swamp Creek on May 24, 1948, ranged in size from 49 to 70 millimeters (fork length) and had an average count of 1,293,400 erythrocytes per cubic millimeter of blood. The blood counts of these wild fish ranged from 880,000 to 1,550,000 red cells. Eighteen hatchery fish that were collected on May 26, 1948, ranged in size from 46 to 66 millimeters (fork length) and averaged 1,435,800 erythrocytes (range, 1,020,000 to 1,705,000). In other words, the hatchery fish averaged 142,000 erythrocytes more than the presumably adequately fed stream fish.

Observations made in July gave the same general results. Eleven wild fingerlings collected in Swamp Creek on July 16,

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Formerly U. S. Public Health Service Research Fellow, stationed at the School of Fisheries, University of Washington, Mr. Katz is now with the U. S. Public Health Service, Environmental Health Center, Cincinnati, Ohio.--The EDITORS.

1948, ranged in size from 40 to 62 millimeters (fork length) and had an average count of 1,605,000 erythrocytes (range, 1,335,000 to 1,765,000). Ten hatchery fish that were collected on July 28, 1948, ranged in size from 50 to 72 millimeters (fork length) and averaged 1,689,000 red cells (range, 1,510,000 to 1,855,000). Again the hatchery fish had the greater number of erythrocytes.

Though the number of erythrocytes is only one of several criteria for determining health in fish, it is apparent that these hatchery fish are not inferior to the wild silver salmon in this one respect. Fish-culturists have apparently improved diets and other hatchery practices so that for a few months, at least, hatchery fish are equal hematologically to the wild fish in their natural stream environment. The observations of Gorham and Marsh, it seems, are not applicable to modern trout and salmon culture.

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A new type of asbestos cement pipe, not heretofore available in the eastern half of the United States, is being installed at the U. S. Fish-Cultural Station at Nashua, New Hampshire. Although similar to the conventional rubber-ring type, this pipe is designed for a maximum head of 58 feet (25 pounds) and sells at a greatly reduced price. As most hatcheries have operating heads within this range, the pipe should find ready acceptance.

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Even fish are traveling by air these days. On June 3, 1949, personnel of the U. S. Fish-Cultural Station at Tishomingo, Oklahoma, delivered to the airport at Pauls Valley 15,000 largemouth black bass fingerlings needed for stocking lakes at the Rocky Mountain Arsenal at Denver, Colorado. A C-47 transport plane then moved the fingerlings (placed in 50 Fearnow pails) from Pauls Valley to Denver in approximately 3 hours.

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# PERCENTAGE RETURNS OF MARKED TROUT IN TWO WEST VIRGINIA STREAMS

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Early in the spring of 1947 the senior author recognized the need for data on the return of trout stocked in West Virginia's streams. Many years of trout stocking had passed, yet no information on the effectiveness of hatchery plantings of trout was available for State waters.

Seneca Creek, a tributary of the North Fork of the South Branch of the Potomac River, was chosen in 1947 as the first experimental stream in which marked trout were placed (Swasey 1948). The following year the North Fork of the Cherry River, of the Ohio River drainage, was set up for comparison with Seneca Creek, which is a part of the Atlantic drainage.

## Seneca Creek

Seneca Creek has its source between the Spruce Knob and Allegheny Mountain sections of West Virginia, a section containing the highest elevations in the State. Seneca Creek flows from an elevation of 4,067 feet at its head to 1,567 feet at the mouth. This represents a descent of 132.12 feet per mile over 19.3 miles. The stream flows over sandstone shales and limestone. It has some long rapids, is quite torrential in places, and contains large flat sandstone rocks and irregular boulders in the lower regions. Flowing through a V-shaped valley, the stream drains an area of 68.37 square miles of second-growth timber. A large fall, approximately 30 feet in height, is located about midway on Seneca Creek. Generally, brook trout are found in the area above the fall and rainbow trout are found below. Seneca Creek is well known throughout the State for fine trout fishing and has been considered an ideal trout stream for many years.

## North Fork of Cherry River

Not unlike Seneca Creek, the North Fork of the Cherry River rises in high mountain country and flows through second-growth timber down a narrow valley with steep, rugged slopes. From its source at an elevation of 4,400 feet, this stream descends to 2,195 feet at the town of Richwood, where it enters the Cherry River proper. In its 17-mile course the North Fork drains 36.39 square miles and falls 118.5 feet per mile. This stream has less fall than Seneca Creek, but the stream bed certainly is more rugged and rough. Except in the upland grass meadows (which are inhabited by brook trout), the North Fork has huge sandstone boulders, large deep pools, and rough rapids. A first-class highway follows the stream throughout its length.

## Marking Methods

All brook and rainbow trout were marked by the cutting of various fins. The trout were marked at the hatchery where they had been raised and then were held there a few days or more before stocking. A total of 17,250 rainbow and brook trout were marked and released in these two

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This paper was presented before the American Society of Ichthyologists and Herpetologists at the June 18-21, 1949, meeting in Washington, D. C.

streams. The brook trout averaged 7 inches in length, and the rainbows averaged 9 inches. Seneca Creek was first stocked in the spring of 1947; stocking of the North Fork was begun in the fall of the same year. All plantings of trout were well scattered over many miles of each stream. Spring plantings were made several weeks prior to the opening of the season. An anesthetic, Ethyl carbamate, was used successfully during the marking of trout in the spring of 1949.

## Creel Census

No attempt was made to secure a complete check of the anglers on each stream during the 2-week checking census at the beginning of each trout fishing season. As anglers could not be obligated to report their catch, a volunteer checking-station system was combined with a random-sample system of checking anglers when they could be accosted along the stream. Each year newspaper publicity was given to the census and the cooperation of the public was requested. Fifty-three days were spent in checking anglers during the 3-year project: 38 days were used in checking anglers on Seneca Creek, and 15 days of creel-censusing were recorded for the North Fork of Cherry River.

Table 1 shows the percentage of return of marked brook and rainbow trout planted in Seneca Creek; table 2 shows like data for the North Fork of Cherry River. These tables are not concerned with the unmarked fish caught by anglers in the two streams. Owing to circumstances beyond the control of the authors, some unmarked trout were stocked in the two experimental streams during the course of this study.

From a total of 9,200 marked brook and rainbow trout stocked in Seneca Creek, a return percentage of 21.8 was recorded (table 1). Of the brook trout planted, 30.5 percent were recovered; while only 14.9 percent of the rainbows reached the anglers' creels during the census periods. Except for the fall stocking of rainbows, the percentage of return of brook trout each year was much higher than that of rainbows. A percentage return of 10.7 was found the spring following a fall stocking of 1,000 legal-sized adult rainbows in Seneca Creek.

A total of 8,050 brook and rainbow trout were fin-clipped and released in the North Fork of Cherry River. These plantings yielded a return percentage of 5.8. In this stream, as in Seneca Creek, a greater percentage of brook trout than of rainbows reached the anglers' creels. By years, the brook-trout return percentages on this stream also were greater. One fall planting of 1,000 legal-sized rainbow trout showed a percentage return of only 0.2 (table 2) the following spring. During this study,

TABLE 1.--Marked trout planting and recovery data for Seneca Creek

| Year | Season | Species of trout | Number planted | | Recoveries | | |
|---|---|---|---|---|---|---|---|
| | | | | | Number | | Percentage |
| 1947 | Spring | Brook | 1,500 | | 557 | | 37.1 |
| 1947 | Spring | Rainbow | | 1,000 | | 88 | 8.8 |
| 1947 | Fall | Rainbow | | 1,000 | | - | - |
| 1948 | Spring | Brook | 1,600 | | 461 | | 28.8 |
| 1948 | Spring | Rainbow | | 1,600 | | [1]446 | [2]27.9 |
| 1949 | Spring | Brook | 1,000 | | 232 | | 23.2 |
| 1949 | Spring | Rainbow | | 1,500 | | 226 | 15.1 |
| Totals | | | 4,100 | 5,100 | 1,250 | 760 | |
| Total percentage return | | | | | 30.5% | 14.9% | |
| Percentage of return for both species | | | | | | | 21.8 |

[1] Includes 107 fall-stocked rainbows.
[2] Fall-stocked rainbows, 10.7%.

TABLE 2.--Marked trout planting and recovery data for North Fork Cherry River

| Year | Season | Species of trout | Number planted | Recoveries: Number | Recoveries: Percentage |
|---|---|---|---|---|---|
| 1947 | Spring | - - | - - | - - | - |
| 1947 | Fall | Rainbow | 1,000 | - | - |
| 1948 | Spring | Brook | 1,800 | 103 | 5.7 |
| 1948 | Spring | Rainbow | 2,250 | [1]82 | [2]3.6 |
| 1949 | Spring | Brook | 1,000 | 110 | 11.0 |
| 1949 | Spring | Rainbow | 2,000 | 173 | 8.6 |
| Totals | | | 2,800 | 5,250 | 213 | 255 | |
| Total percentage return | | | | | 7.6% | 4.9% | |
| Percentage of return for both species | | | | | | | 5.8 |

[1] Includes 2 fall-stocked rainbows.
[2] Fall-stocked rainbows, 0.2%.

plantings of 2,800 marked brook trout yielded a return of 7.6 percent and 5,250 marked rainbows showed a return of 4.9 percent.

## Discussion

These data offer nothing new or startling in findings on marked hatchery-reared trout (Shetter 1947). The original purpose behind marking trout in these two West Virginia streams was to determine the effectiveness of our trout stocking program. Ridiculous as it may seem, native sportsmen of the State seem to choose to ignore what findings may have been recorded for other States, therefore requiring us to make specific surveys in West Virginia to determine what our streams will show. It is, of course, advantageous for us to conduct studies of like nature for comparison with other States' findings, although the new studies may add nothing unusual to our over-all knowledge of trout streams.

The percentage of return of adult, legal-sized brook and rainbow trout--raised at great cost in State hatcheries--certainly is low in West Virginia when compared with what expectations we may have, what the angler may wish, and what other workers have found to be true elsewhere (Trembley 1945).

In West Virginia we have great concern over our trout-management program. We have not the funds, and perhaps will never have sufficient funds, to supplement our "native" trout-stream production with hatchery-reared fish to meet the demands of our ever-increasing fishing public. We shall have to concentrate our efforts upon increasing the percentage of catch by anglers, employing (as we are) experimental methods of stocking to accomplish this.

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## LANOLIN TO THE RESCUE

The rough, cracked hands of the fish-culturist are a "badge of courage"--a very painful one--most frequently displayed during draining and delivery time. William H. Brown, aquatic biologist with the Texas Game, Fish and Oyster Commission, reports that this painful condition of the skin may be alleviated by the application of a small amount of lanolin before and after exposure to wind and water.

Lanolin, produced from wool fat, is a mixture of the esters of cholesterol, the natural oils and fats of the skin--and thus the best lubricant for the skin. The lanolin must be thoroughly rubbed into the skin of the hands and arms.

Lanolin is packaged in tubes and is usually available at the corner drugstore under the name of lanolin hand cream or toilet lanolin, or some such title. Some preparations even have fragrant essences added. Brown suggests that perhaps the fish-culturist of the future will reek of an essence of lilac instead of fish and meat scraps.

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A short time previous to hatching, the investing membrane of the egg becomes yellowish-brown in color, and a floss-like coating envelops it, reminding one by its appearance of the much-dreaded byssus. The movements of the fish, which may have been noted as early as the thirtieth day, become more and more rapid. The previously noticed movements were gentle motions of the tail, but now the whole body seems violently convulsed. At length, with a violent effort, the shell is broken, and the little fish is born. What part first appears to the external world is a matter of perfect indifference. We well remember the consternation of one of our customers on the occasion of a whole tray of eggs hatching tail foremost, when the only work on fish culture in his possession, and in which he had placed the most implicit confidence, declared that the head invariably appeared first. By concentrating upon the mature egg the sun's rays, by means of a lens, the birth may be hastened, and the efforts of the fish, by which the shell is ruptured, plainly seen. This can only be done as an experiment, as the forced birth is generally fatal to the fish. Head, tail, back, and even the yolk sac may first appear. After breaking the shell it frequently happens that before emerging entirely the troutlet rests for a short time, apparently for the purpose of regaining its strength exhausted by its labors. Some writers have recommended that the shell be removed in this case, by gently passing over the body of the fish a fine camel hair brush. This, in our hands, has not been successful, meddlesome midwifery being followed by its usual results. If the fishes are strong and healthy they will in time clear themselves, and if not, they will surely die in a short time.

--J. H. Slack, "Practical trout culture." New York, 1872.

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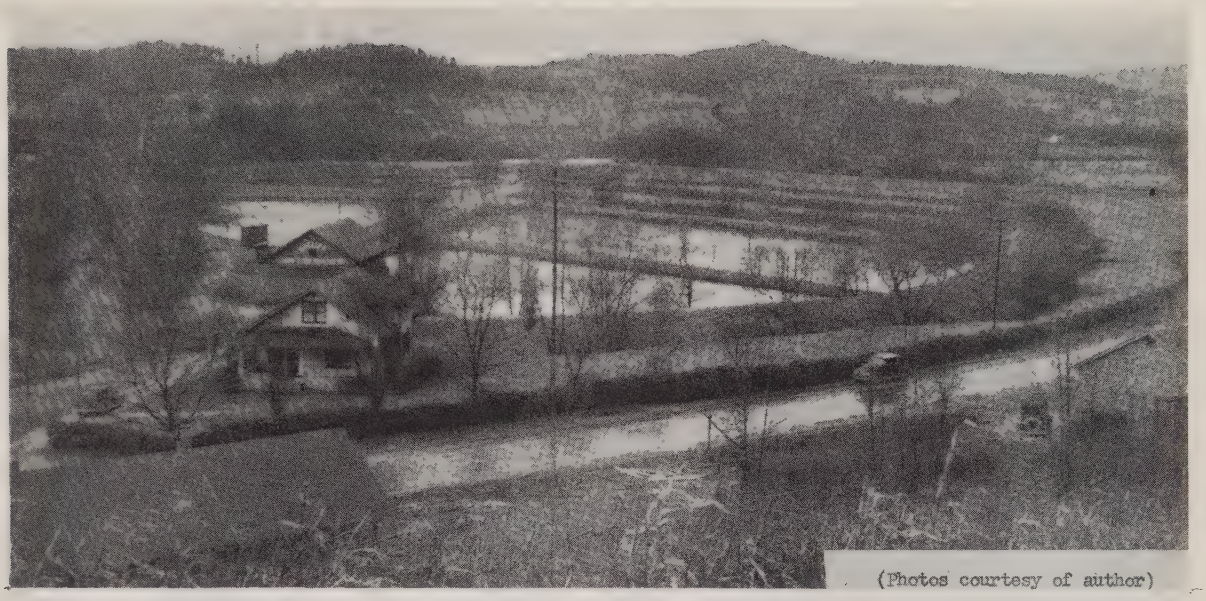

(Photos courtesy of author)

Gatliff State Fish Hatchery.
Pond used for fry production is the second on right behind house.

# BASS PRODUCTION IN A KENTUCKY FISH HATCHERY POND

Minor Clark
Division of Game and Fish
Frankfort, Kentucky

Kentucky fish hatcheries are small as compared with the demand for bass to supply farm ponds, lakes, and streams of the State. In addition to stocking State-owned rearing ponds, rearing ponds operated by various sportsmen's clubs, and about 5,000 farm ponds and lakes, we must supply fingerling bass to 168 sportsmen's clubs for stocking streams and lakes. The majority of the clubs get about 1,000 fingerling bass each. Such bass have to be produced in 12.66 acres used for both hatchery and rearing and in 8.85 acres used for rearing only.

During the early days of our farm fishpond program it was discovered that if farm ponds were stocked with bass fry, such bass matured that year and spawned the following season; thus fishing could be available in 1 year. On the other hand, if fingerling bass were planted in Kentucky ponds in July and August, the bass did not spawn the following season, ponds became too heavy with bluegill, and fishing had to be delayed for 2 years.

For these reasons, it was decided to select one pond at the Gatliff State Fish Hatchery and keep it stripped of fry as produced. This 1.52-acre pond contained 125 largemouth bass brooders ranging in size from 3/4 to 2-3/4 pounds. As listed in the table, more than 585,000 fry were taken from the pond between April 26 and May 25. The additional harvest of more than 29,000 fingerlings (1-1/2 to 5 inches in length) from the same pond between June 7 and July 20, however, indicates that efforts to remove all fry from this pond were unsuccessful.

**In effort to have each fish well fed, much time is spent in feeding brood bass.**

Largemouth bass fry and fingerlings removed from one pond

| Size | | | Date removed | Number |
|---|---|---|---|---|
| Fry | | | 4-26-49 | 85,000 |
| Do. | | | 5- 3-49 | 97,000 |
| Do. | | | 5- 5-49 | 147,000 |
| Do. | | | 5- 6-49 | 18,000 |
| Do. | | | 5-10-49 | 90,000 |
| Do. | | | 5-17-49 | 61,685 |
| Do. | | | 5-24-49 | 2,250 |
| Do. | | | 5-25-49 | 85,000 |
| | | TOTAL | | 585,935 |
| Fingerlings, | 1-1/2 | inches | 6- 7-49 | 15,500 |
| Do. | 1-3/4 | do. | 6-10-49 | 200 |
| Do. | 3 | do. | 7- 6-49 | 11,361 |
| Do. | 2-1/2 | do. | 7-12-49 | 2,100 |
| Do. | 5 | do. | 7-20-49 | 60 |
| | | TOTAL | | 29,221 |

All brood bass from the other six ponds of the hatchery were transferred to this pond during the weeks of June 6 and June 13. No effort was ever made to drain the pond. Fingerlings were removed with a 30-foot minnow seine used around the banks and at the inlet after fresh water had been added.

An exceptionally large number of fry was produced in the other ponds at Gatliff, but no effort was made to remove any fish from them. All available trucks and all the men who could be sent to the station were tied up in collecting, counting, and distributing fish taken from the single pond. Results during the past 12 years have indicated that hatchery ponds produced more fingerlings when the fry needed were obtained from only one or two ponds, but results did not so indicate at Gatliff or at other stations in 1949.

Perhaps it should be pointed out that only a mixture of sheep manure and superphosphate was used in fertilizing the pond. As was to be expected, practically no bloom developed and fry were easily located. No fertilizer of any type was added after the nesting season, and the pond did develop a fair bloom about June 7 in the absence of fertilizer.

It is believed that success at the Gatliff Hatchery may be attributed largely to care in feeding brood stock throughout the year. Chopped liver, beef heart, horse meat, and tripe are used at various intervals. Every effort possible is made to see that all bass are feeding when food is being thrown into the pond.

# BLACK BASS IN MARYLAND

Talbott Denmead
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In several recent publications there have been statements to the effect that the black bass introduced in Maryland around 1853 or 1854 by William Shriver, who brought them from the Ohio River watershed in the water tank of a Baltimore and Ohio locomotive and placed them in the Potomac River, were largemouths. One publication refers to the fact (?) that the black bass of our Maryland tidewaters were "originally imported from the upper Ohio River system." Another notes that "although these fish were originally imported from the upper Ohio River system, they have fared surprisingly well in the brackish headwaters of the Chesapeake Bay"--and so on.

The black bass brought over the mountains from Ohio by Shriver--or Stabler, who, as the conductor on the Baltimore and Ohio train, handled the shipment or shipments--were smallmouths. The earliest reference to this transplant seems to be by Eoff in the 1854 Report of the Smithsonian Institution: "Mr. William Shriver, a gentleman of this place [Wheeling, W. Va.], and son of the late David Shriver, esq., of Cumberland, Maryland, thinking the Potomac river admirably suited to the cultivation of the bass, has commenced the laudable undertaking of stocking that river with them; he has already taken, this last season, some twenty or more in a live box, in the water tank on the locomotive, and placed them in the canal basin at Cumberland, where we are in hopes they will expand and do well, and be a nucleus from which the stock will soon spread."

In a letter dated September 1860 to Philip T. Tyson of Baltimore (Agricultural Chemist of Maryland), General Shriver writes: "... The enterprise or experiment was contemplated by me long before the completion of the Baltimore and Ohio Railroad to the Ohio River at Wheeling, but no satisfactory mode of transportation presented itself to my mind until after the completion of the great work (in, I believe, the year 1853), and in the following year I made my first trip (although I made several afterwards in the same year), carrying with me my first lot of fish in a large tin bucket, perforated, and which I made to fit the opening in the water-tank attached to the locomotive, which was supplied with fresh water at the regular water stations along the line of the road, and thereby succeeded well in keeping the fish (which were young and small, having been selected for the purpose) alive, fresh, and sound.

"This lot of fish, as well as every subsequent one, on my arrival at Cumberland, were put into the basin of the Chesapeake and Ohio Canal, from which they had free egress and ingress to the Potomac River ..." (Henshall 1889: 158-159.)

A letter (dated October 28, 1865, and published that month in the Baltimore Sun) from Edward Stabler to G. T. Hopkins of the Board of Water Commissioners of Baltimore, reads: "... I have succeeded in

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**Since his retirement from the Fish and Wildlife Service on January 31, 1947, Mr. Denmead has undertaken assignments for the Maryland Game and Inland Fish Commission. --The EDITORS.**

taking in the Upper Potomac, and safely transporting to Baltimore, a fine lot of 'Black Bass' (Grystes nigricans Agassiz), with which to stock 'Swan Lake,' and also those in Druid Hill Park.

"As a brief history ... may not be without interest to some, it may be stated that some thirteen years since, my son, A. G. Stabler, then a conductor on the Baltimore & Ohio Railroad, in connection with two public-spirited gentlemen of Wheeling (Forsythe and Shriver), brought from Wheeling Creek, West Virginia, a small lot of Bass in the water-tank of his tender. They were placed in the Potomac, near Cumberland, and from this stock, the Potomac, for more than two hundred miles, and all its large tributaries /mentioned by name/ afford fine fishing." (Henshall 1889: 159-160.)

In the Baltimore American of June 1874, an article on fish culture refers to this transplanting and mentions J. P. Dukehart, as well as Stabler and Forsythe. It seems safe to say, therefore, that all these gentlemen were interested and assisted in this undertaking. Dr. J. A. Henshall, who was born in Baltimore, was of the opinion that there was no evidence to show more than one shipment. Shriver's letter to Tyson, however, leads one to the contrary view; and it stands to reason that all these waters were hardly stocked with a single shipment of some 30 small bass. They were smallmouths.

About 1850, scientists called both largemouths and smallmouths Micropterus salmoides, a name later applied mostly to largemouths. Undoubtedly, this has caused the confusion regarding the species that actually was put into the Potomac. In his "Book of the Black Bass," Henshall gives plenty of evidence that the smallmouth was called salmoides and that this name should be "restored" to the largemouth, and dolomieu should be assigned to the smallmouth. Jordan's comment is cited by Henshall (p. 44): "It is thus evident that Cuvier and Valenciennes completely confounded the two species under Grystes salmoides ..."

In 1850, Agassiz recognized the generic identity of the forms already described by LeSueur, Cuvier, and Valenciennes, and retained the name Grystes for these black bass; his smallmouth, however, was Grystes fasciatus, in contrast with G. salmoneus and G. nigricans. In 1857, about the same time that the Potomac River was first stocked, Garlick described the smallmouth as Grystes nigricans. Two years later, Gunther (Henshall 1889: 28) described specimens of the smallmouth as Grystes salmoides. In 1866, Cope named the largemouth Micropterus nigricans. Omitting the papers of less importance, we come finally to the very able discussion of these questions by Gill (1873), by whom the whole subject is treated exhaustively and the name Micropterus salmoides is definitely adopted for the small-mouthed bass. Gill is quoted as saying: "But one of these types, the small-mouthed, appears to have been an original inhabitant of the hydrographic basin of the Ohio River." He further said that he had never seen a "bigmouthed black bass" from the Ohio. If there were no largemouths there, Stabler and the others could not have transported largemouths to Cumberland.

Jordan, in 1879, writes: "The name Micropterus salmoides is now generally adopted in America as the proper name for the small-mouthed Black Bass." And Henshall (p. 51) writes of his conviction that "M. dolomieu should be restored to the small-mouthed black bass." Much additional evidence can be supplied to show that scientists, when the Potomac was stocked, were confused as to these two species, and that salmoides was used for the smallmouth or for both species. According to Hubbs (1940: 8, 36), the two species are Micropterus dolomieu (Lacepede) for the smallmouth and Huro salmoides for the largemouth. Let's stick to these in the future and avoid more confusion.*

Every old-timer who fished in the Potomac and tributaries years ago will tell you that the fish he caught were

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***As appearing in "A List of Common and Scientific Names of the Better Known Fishes of the United States and Canada," Special Publication No. 1 (1948) of the American Fisheries Society:**

**Smallmouth black bass - Micropterus dolomieu**

**Largemouth black bass - Micropterus salmoides**

**--The EDITORS.**

smallmouths, and that there were no largemouths in those waters until recent years. I fished the Potomac near Hancock during two summers around 1890, and all we caught were smallmouths. Frank L. Bentz (member, Maryland Game and Inland Fish Commission), born and raised in western Maryland, and a fisherman on these waters all his life, says: "They were smallmouths. Only in recent years have largemouths been introduced into these waters, and then with only fair success; they do not seem to thrive as well there as smallmouths. Even today I doubt if largemouths, after considerable stocking, comprise more than a very small percentage of the angler's catch." And so it goes. The black bass planted in the Potomac River near Cumberland--the fish which stocked the whole system--were smallmouths.

And now, how did the largemouths get into our brackish tidal waters at the head of the Chesapeake Bay? Certainly they did not come up the Bay through the strong salt waters: the fish would have perished. They could have come down the Susquehanna River, but did they? According to Uhler and Lugger (1876: 130), largemouths were "introduced into the Potomac River from the Youghioghany River, now abound in some of the upper parts of that stream; likewise in the C. & O. Canal, and have become naturalized in Lake Roland near Baltimore." The Yough drains into the Ohio watershed. The black bass in Lake Roland during my boyhood and later were smallmouths. It would seem, therefore, that Uhler and Lugger made the same mistake--confused the two species by a mix-up in scientific names. I am not personally familiar with the species of black bass in the Yough; the part of the Yough in Maryland is trout water and so badly polluted that no fish life is there. I feel sure, however, that an investigation will show that back in the 50's the bass of the Yough, in Pennsylvania, were smallmouths.

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... If you put sheep on a pasture and starved them, so that they ate up the very roots of the grass, you would easily understand that until you sowed and grew more food you could keep no more sheep; yet you cannot or will not apply the same rule to an overstocked stream, and you will not till nature shows it to you forcibly. The value of your stream is in the ratio of the food it produces, and not an atom beyond. If it produces no food it is valueless.

--Francis Francis, "The practical management of fisheries: a book for proprietors and keepers." London, 1883.

... I believe that the worst persons to go to, if knowledge of fish is required, are fishermen. They, as a rule, know very little, and they supplement their ignorance by mendacity, the measure of the mendacity being the amount the inquirer will swallow. They always tell you things used to be better than they are now and that something or other is ruining them. They know how to catch the fish, but only by a rule of thumb. A more obstinate, opinionated set of men it is impossible to find. They will give no information as to the habits of fish, and they decline to answer any questions as to the take of fish, and if you rely on their information you always find that any conclusions you draw are utterly wrong. ...

--J. W. Willis Bund, "Salmon problems." London, 1885.

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You don't buy a paper -- you invest in news.
You don't buy glasses -- you invest in good vision.
You don't buy theatre tickets -- you invest in entertainment.
You don't buy insurance -- you invest in protection.

You don't buy a fishing license -- you invest in sport and recreation for yourself and the next generation.

—Adapted from Cold Facts (National Association of Refrigerated Warehouses, Washington, D. C.)

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# AN APPLICATION OF ELECTRICITY TO COLLECTION OF FISH

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An electric fishing device has been found useful in the collection of living, uninjured specimens of cutthroat trout.

In western Oregon many difficulties attend collection of fish during most of the year. Owing to high-water conditions in the lower streams through fall, winter, and spring, the seining of fish is many times impracticable. Collecting operations during these seasons are necessarily confined to upper tributaries and small brooks. In this region practically all of these smaller streams are lined with dense vegetation and are choked with obstructions which prohibit ordinary use of the seine. These streams are rapid and consist of relatively deep pools alternating with breaks and riffles. The overhanging border vegetation and the limbs and slash in the water provide many small areas of comparatively quiet water and excellent cover for trout (figure 1).

Collecting equipment for use in this type of habitat should be easily carried by one man and be suitable for handling in dense undergrowth, in addition to being effective in the collection of fish. As it is desired that the fish be collected free of injuries, the problem is further complicated.

The principle of the electric apparatus described by Shetter (1948) was applied to this problem with good results. Because of difficulty in handling as well as because of initial expense, the equipment used by Shetter was not feasible for the local problem.

(Photos courtesy of the author.)

FIGURE 1. A section of a small stream where some collecting has been done. A tributary of Marys River, Benton County, Oregon.

The device used in the work here has as its source of power a six-volt "hot shot" dry battery weighing about 12 pounds. By means of heavily insulated 11-gauge copper wire, the battery is connected to an induction coil of the type used in the ignition system of a Model "T" Ford. A vibrator on this coil automatically opens and closes the circuit, causing the voltage to be stepped up. The output of this set-up is not definitely known, but Mr. Ralph N. Lunde of Agricultural Engineering in the Oregon Agricultural Experiment Station states that this battery and coil, when used in the conventional ignition system, deliver a very small fraction of an ampere at about 15,000 volts. The ends of the wires from battery to coil and the wires leading from the coil are soldered to the coil posts and heavily bound to the coil box

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Technical Paper No. 583, as approved by the Director of the Oregon Agricultural Experiment Station. Contribution of the Department of Fish and Game Management.

FIGURE 2. Power source. The cover has been removed from the vibrator of the coil.

with friction tape. Tape is wound on the box to form a protective covering. A pasteboard lid placed over the vibrator and the end of the coil box is securely taped into position with several wrappings. The tape is cut around the edge of this cover to facilitate removal for adjustment of the vibrator. The cover is held in place by four or five wrappings of tape around the junction of cover and box. The heavy layer of tape prevents the interruption of functioning that would otherwise be caused by water splashings during operation; the tape also prevents disconnection of, or strain on, soldered connections during movement of the operator through dense undergrowth (figure 2).

The leads from the coil are 3 feet long; each extends to one of two 9-foot bamboo poles. The leads are looped to their respective extension wires and are heavily taped at this union. This joint permits more motion of the wire, eliminating the undue bending which otherwise occurs at this point. The extension wires are securely taped to the bamboo poles. Each extension reaches from a point about 2 feet from the butt of its bamboo pole to 10 inches from the end, where it is soldered to a 1/32-inch copper plate. These plates are 9 inches long by 1-1/2 inches wide and serve as electrodes. Each electrode is bound to the end of its respective pole with two short lengths of copper wire and is securely taped.

One of the two wires between the battery and the coil is fixed to a battery post; the other wire is connected to the other battery post by a clip which provides the means of starting and stopping the flow of current.

During operation, the battery and coil are carried in a musette bag slung across the operator's shoulder. The poles are extended into the water so that the electrodes are submerged, and the current is started by affixing the clip to its battery post. The operator grasps both poles near the junction of the lead and extension wires, steadying the poles by gripping the base of each pole between the upper arm and side of the body (figure 3). When using the device, the operator wears rubber-impregnated gloves and rubber boots. Thus far, only mild shocks have been experienced during operation; these shocks have occurred only when the electrodes have been removed momentarily from

the water during negotiation of stream obstructions. The device is not considered dangerous, but the shocks are distracting if insulating gloves and footgear are not worn.

When collecting, the operator holds the electrodes 2 to 5 feet apart upon entering a pool and works downstream. The poles are manipulated so that likely areas are spanned by the electrodes, and the latter can be thrust into otherwise inaccessible areas eroded under banks and among logs, rocks, and brush. Fish caught between the electrodes are stunned and struggle in a feeble, indecisive manner. These movements carry them from the quiet water of their hiding places into the stream current, which sweeps them into a seine stretched across the riffle below. Only short lengths of stream--perhaps individual pools 10 to 20 feet long--should be worked at one time, as the fish sink to the bottom and are lost among obstructions if allowed to drift for any great distance. If the electrodes are held more than 5 or 6 feet apart, the voltage is built up to such an extent that the operator begins to feel some of the shock. It is assumed that this distance would vary, depending on the electrolyte content of the water.

As noted by Shetter (1948), the larger fish suffer the more adverse effects, but no mortality that could be attributed to the electric shock has taken place among the fish collected. Of fish collected in this manner, those longer than 6 or 7 inches were sluggish in laboratory tanks for a time but appeared to suffer no permanent injury. No ill effects of shocks received in the stream have yet been noted among fingerling trout collected. Laboratory tests involving fish exposed to prolonged periods of discharge resulted in mortality.

The factors of electrolyte content of the water and of substrate types and their relationship to similar problems have been discussed by earlier investigators (Haskell and Zilliox 1941). No studies concerning these matters have been made with reference to operation of the equipment described in this paper.

Construction of the above-described apparatus cost only slightly more than $10, and for this reason it can be considered for the average budget.

FIGURE 3. Operator demonstrating position in which the poles are usually held.

For collecting in the type of habitat described in this paper, this device is believed to be satisfactory. In the experience of the personnel at this station, the apparatus is practical only where the cover areas are small enough to be spanned by the functional distance of the electrodes. The water must be swift in order that the fish will be swept into the seine; otherwise, they will fall to the bottom and lodge among stones and debris, where they will be hidden by the turbulence and/or turbidity of the water. Collecting might be possible in quiet waters of such clarity that the fish could be easily seen and dipped out after being stunned.

Although no quantitative work has been done with this equipment, it is believed that by using two seines as described by Haskell (1940), census work could be conducted in many streams that do not lend themselves to other methods.

Prof. Fred O. McMillan, Head of the Department of Electrical Engineering, Oregon State College, states that with

a knowledge of the resistivity of the water, and the type and desired working distance of the electrodes, a coil could be constructed that would provide a voltage gradient closely approximating a desired value. Such a modification would make the device more specific for the particular waters in which collecting was desired. This change in the apparatus could be made if the induction coil mentioned in this paper did not produce the desired results.

Acknowledgments

The writer wishes to thank Mr. Ralph N. Lunde for his information concerning the output of ignition coils, and to thank Prof. Fred O. McMillan for his very informative discussions on the principle and operation of such electrical equipment. Prof. McMillan suggested the modification of the coil--which would undoubtedly be a desirable feature under many circumstances.

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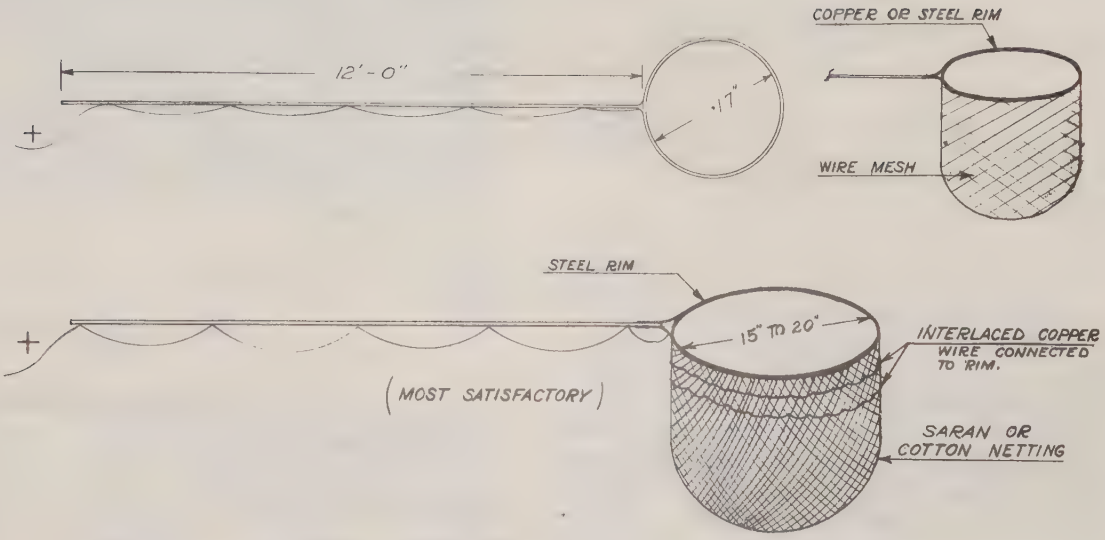
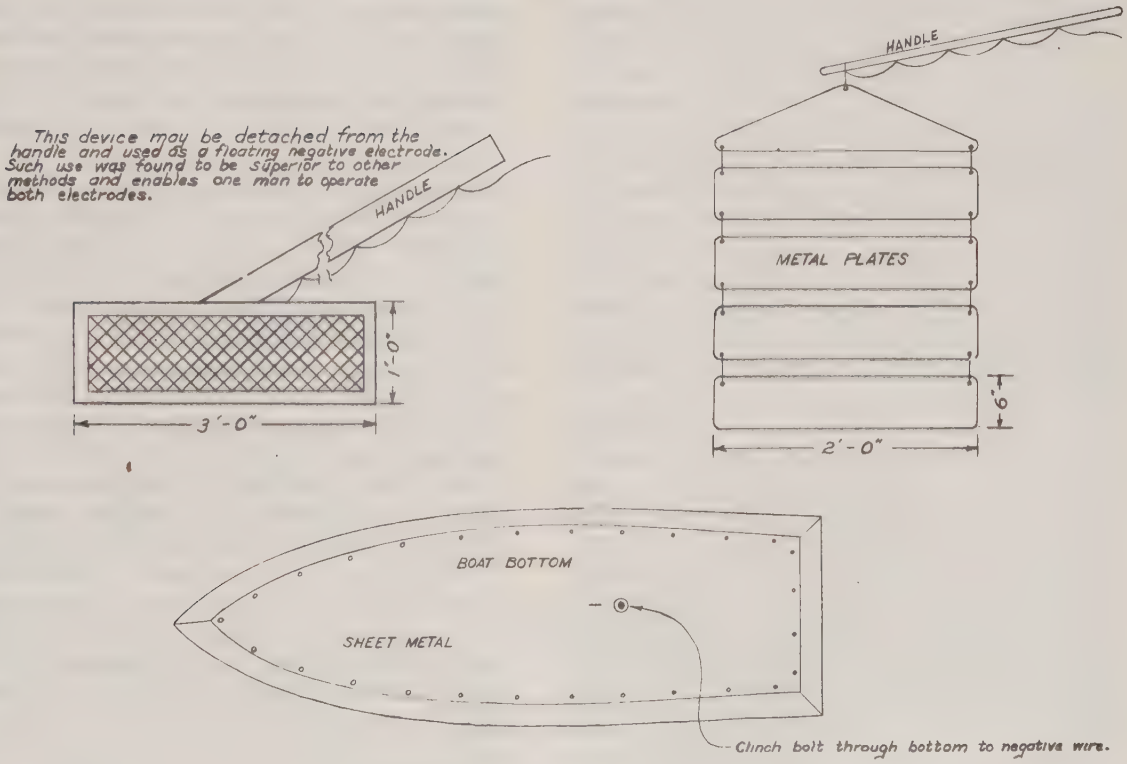
## ELECTRODES USED IN ELECTROFISHING

Electrofishing as a means of collecting fish has been the subject of considerable study by the fishery staff of the Oregon State Game Commission. A number of electrodes have been devised, and some of these have been more satisfactory than others. H. J. Rayner, who submitted the article entitled "Direct Current as an Aid to the Fishery Worker" (THE PROGRESSIVE FISH-CULTURIST 11 (3): 169-170), has contributed a drawing (opposite page) of several electrodes which may be of assistance in electrofishing.

## POSITIVE ELECTRODES




## NEGATIVE ELECTRODES


This device may be detached from the handle and used as a floating negative electrode. Such use was found to be superior to other methods and enables one man to operate both electrodes.
HANDLE
1'-0"
3'-0"
HANDLE
METAL PLATES
6"
2'-0"
BOAT BOTTOM
SHEET METAL
Clinch bolt through bottom to negative wire.

ELECTRODES USED IN ELECTROFISHING
AS MODIFIED FROM THOSE DESCRIBED
IN "ELECTROFISHING" BY DR. K. SMOLIAN.

# NATURAL SIPHON EGG PICKER

A. B. Smith
Oak Springs State Hatchery
Maupin, Oregon

The removal of dead eggs from th hatchery trough has long posed a proble Since the days of the hand tongs, many a device has been introduced in an attempt to simplify this basic hatchery operation. With slight variation, the picker herein described has been in use for the past 10 years at the Oak Springs State Hatchery.

As shown in figure 1, through the lid of a large glass jar--a coffee jar is often used--two small metal tubes (approximately 1 inch long) are soldered, and to these tubes are attached two 30-inch pieces of soft, pure-gum surgical tubing. One piece of surgical tubing is allowed to hang freely, acting as the overflow. The other piece is attached to a curved glass tube of the hospital drinking-tube type. This glass tube is used for removal of the eggs from the basket and should have a very full bend to allow free passage of the eggs. Many operators find that a curved tube increases speed.

It has been found that the minimum wall for the surgical tubing, to prevent collapse, is about 1/16 inch thick. The diameter is, of course, chosen to pass easily the largest eggs handled by the hatchery. The main glass tube is also selected to accommodate the largest size of eggs expected. As shown in figure 2, a smaller tube may be inserted into the tube and an airtight coupling made. This allows use of the same equipment on smaller eggs. For measuring purposes, the glass jar may be calibrated.

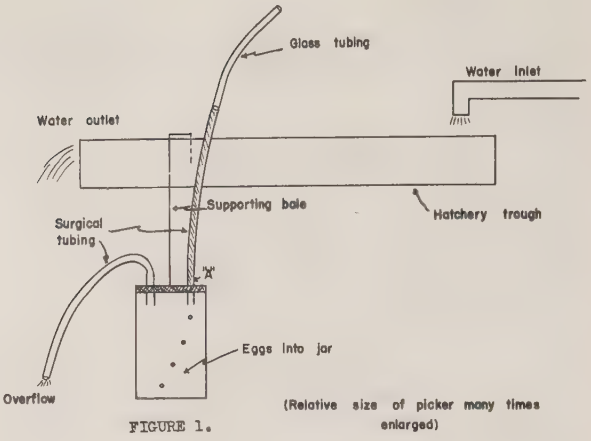



FIGURE 1.

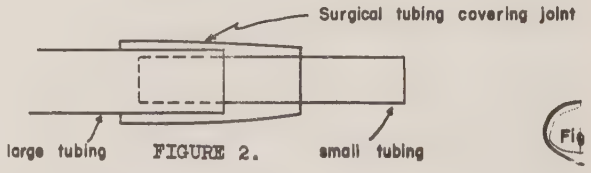



FIGURE 2.

Once the picker is assembled as shown in figure 1 and the siphon is established, the operator should control the water flow by squeezing the surgical tubing between the fingers. Originally a valve was inserted at A (figure 1), but this did not prove satisfactory. The soft surgical tubing causes a minimum of hand fatigue. The position which must be assumed by the operator is also very natural and, therefore, quite comfortable.

The picker described here is extremely easy to use. An average operator can, with limited experience, pick 30 ounces of rainbow eggs per hour. All types of eggs work equally well in the picker. It has performed with complete success on Chinook eggs running 50 per ounce.

At Oak Springs the overflow is allowed to drain away on the floor. Should this be undesirable, a trap may be arranged on a long drain tube. Care should be exercised, however, to prevent introduction of sufficient tubing to slow the water flow unduly.

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See also:

Playfair, A. C.
1939. Syphon egg pick. (letter) Prog. Fish-Cult. 44: 37-38.

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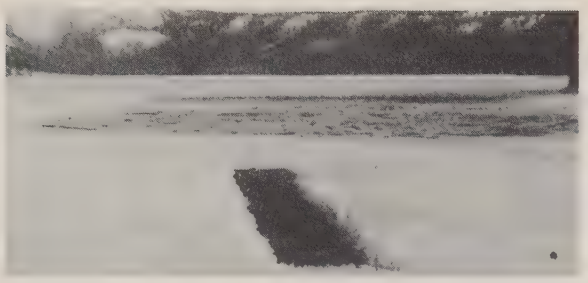
An adjustable screw clamp (obtainable from chemical supply and equipment companies) applied to the overflow tubing would permit the operator to regulate the amount of suction without using hand pressure.--The EDITORS.



Area over spawning ground covered with carbon black. Test strip in foreground.
(Photo courtesy of the author.)

# CARBON BLACK ON EAST LAKE, DESCHUTES NAT'L FOREST, OREGON

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An experiment was conducted in the spring of 1949 on East Lake, Deschutes National Forest, Oregon, to determine the feasibility of using carbon black to open ice-covered water over the rainbow spawning grounds.

The high altitude (6,400 feet) of this lake prevents early melting of the heavy ice cover. For this reason, many spawning rainbow trout are over-ripe before spawning crews are able to seine. It has been believed that if areas over the known spawning grounds could be freed of ice, seining operations could begin at an earlier date and rainbow trout would then be less likely to be over-ripe.

On April 12, 1949, carbon black was applied to the surface of the ice cover on the gravel-bar spawning ground at East Lake. The solid ice was 20 to 24 inches thick, and a layer of snow and slush on top of the ice was approximately 20 inches deep. Approximately 600 pounds of the carbon black was applied by hand over nearly an acre. A test strip (18 by 1½ feet) was also covered with carbon black to enable personnel to measure the rate of melting.

After this application of carbon black, the snow and ice cover melted at the rate of 2 inches per day. Eight days later, three holes, nearly 3 feet in diameter, appeared in the area. The ice on the entire area was melting rapidly when these holes developed. The melting of the ice continued, and 6 days later the entire area was broken. The carbon black had broken the ice cover, the crystals of ice remained in the area in such large amounts that seining was impossible.

The carbon black in solution spread through the slush cover of the lake. It is estimated that at least 200 acres of ice were discolored by the carbon black from the test area. This increased the melting of the main ice cover to such an extent that the break-up of East Lake occurred on the same day (May 15) as that of Paulina Lake. Normally, East Lake breaks 6 to 7 days later than Paulina. Paulina Lake is in the same crater, approximately half a mile west of East Lake.

A few fish were seined before the main break-up occurred, but the main portion of the spawning run did not move into the area until the whole lake was free of ice.

Little evidence of spawning could be found immediately after the ice melted. Very few redds were dug before the break-up. After the lake was free of ice, the rainbow moved into the shoal areas for spawning.

## Conclusions

Carbon black can be used successfully in the early removal of heavy ice coverings on mountain lakes.

The carbon black might be distributed much more adequately by some mechanical device or by airplane.

Opening small areas over spawning grounds appears to be inadequate. Spawning fish did not move in number into these areas until the entire ice cover had melted.

Very few over-ripe fish were found in this season's spawning at East Lake.

...Mr. Ainsworth told me a few days ago, that he kept an account of the expense of feeding his fifteen hundred fish /trout/ on beef's liver for one year, and that the amount so expended was only seven dollars and a half. But in his neighborhood, he can buy a beef's liver for ten cents. ...

--Thaddeus Norris, "American fish-culture." Philadelphia, 1868.

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All who have obtained the least smattering of piscicultural lore are acquainted, at least by name, with the byssus--that terror of fish culturists, regarded by them as a devastating blight, a pestilence walking in darkness, an unpreventable and incurable disease, liable at any time to attack and destroy an entire crop of eggs, against which no precautions can avail, and for which no remedy can be devised.

--J. H. Slack, "Practical trout culture." New York, 1872.

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If part of the expenditure of the agricultural bureau, which produces no immediate benefit to the country, was appropriated to building an efficient fishway around Niagara Falls, and salmon were introduced by artificial culture into the many fine rivers entering the chain of great lakes above, it is difficult to estimate the numbers that would make the Niagara river a highway.

--Thaddeus Norris, "American fish-culture." Philadelphia, 1868.

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I was once coming back from shooting in Wales, and I saw some men at a river trying to gaff a Salmon in the pool. I could not help staying to look, and, as I stayed and saw the fish missed, I could not help thinking that I could do better; and thinking led to trying, and I never was prouder than when I hooked out the fish that professional Welsh poachers had failed to catch. I did not awake to what I had done until one of the men, who felt spiteful at my success, said: "And he calls himself the Chairman of a Fishery Board. I should like to know where he learned, and where he practises gaffing!"

--J. W. Willis Bund, "Salmon problems." London, 1885.

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# PUBLICATIONS

## REPRINT

### AGE DETERMINATION IN FISHES, BASED ON EXAMINATION OF FINRAY SECTIONS

by E. G. Boyko

(Communicated by L. A. Orbeli, Member of the Academy, 16. III. 1946)

The method of age determination according to transverse sections of finrays (lepidotrichia), as suggested by Clair (1), has by now been firmly established in ichthyological practice when studying Acipenseridae and Silurus. Its practical application to investigations of other fish species is, however, restricted to a few studies where thin-sections of finrays were used mainly as controls (2-14) to check the accuracy of scale- and otolith readings. The reason lies in the difficulty to prepare thin-sections of finrays in any great number, as the fins of most fishes, especially of small ones, are very fragile, and do not withstand treatment.

During the work carried out at the Don-Kuban Experimental Fishery Station since 1939, the procedure was much modified, so that by now the possibility of resorting to finrays for age determination has greatly been extended. Sections of finrays can well be obtained from fishes of any size, inclusive fry with a body-length of 4-5 cm. The sections are prepared from whole fins, not of their first hard rays as before. After drying the rays become tightly fixed together by the fin-membranes and slime, so that they do not crumble during the process of sawing. Fins with very fine rays from fishes less than 15 cm. long are embedded in celluloid to make them fit for sawing. The transverse cut (through the whole fin, or, more often through several first rays) is made with a fret-saw with a fine blade, such as is used for work on metal. Of course, much time and labour could be saved by a mechanic sawing device (13).

It was found that work with finrays, all procedures included (from the collecting of fins to the reading of the sections), requires no more time than the work with scales and otoliths, nothing to say of the bones of the operculum and other fish bones. Fins are collected as easily and quickly as scales and the time spent on sawing is compensated for by a more rapid reading as compared to that of scales. The most pains-taking-process, the grinding of the sections, which took sometimes as much as 10 minutes, was found to be unnecessary. The sections are clarified instead with transformer and hair oil, xylene, etc.

The efficiency of the different processes involved in the work with finrays is as follows; Preparation of sections: 200-250 fins per a 7- to 8-hour working day (2 or 3 sections are made from each fin, to serve as controls). Embedding of fins of small fishes in celluloid:

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200-300 fins. Examination of the sections: 300-500 samples (as compared with 100-200 samples when working with scales of Lucioperca lucioperca, Abramis brama and Pelecus cultratus).

Several conditions are to be strictly observed. Thus, the sections must be carefully dried, or, in some cases, heated prior to reading (Salmonidae, Clupeidae and some other fishes) to make visible the annual rings on the sections. The thickness of the sections (0.4-0.5 mm) is of less importance than a proper selection of the direction of the cut precisely across the finrays, etc.

It has been found that the annual rings are formed not merely on hard spiny finrays, but are also well marked on the soft branched rays, which were formerly considered useless for age determinations. Earlier information has found support as to the good visibility of annual rings on sections of finrays of Aspius aspius, Abramis brama, Lucioperca lucioperca, Gadus morhua, Cyprinus carpio, Carassius carassius, as well as of Pelecus cultratus, Rutilus rutilus Heckeli, Vimba vimba, Rutilus frissi, Blicca bjoerkna, Leuciscus idus, Omorhynchus keta, Salmo salar, Sardinops melanisticta, Caspialosa caspia, Caspialosa volgensis, Caspialosa pontica, Mugil saliens and Mugil cephalus. It was the first time that fins of these fishes were taken for age determinations. No annual rings were found on the fins of Sarda sarda whose rays are characterized by a delicate long base and large internal cavities. In the overwhelming majority of fishes listed above the annual rings are more distinctly expressed on their finrays than on the scales. Number of additional rings on the sections is smaller than in the scales, and these are more readily distinguished from the annuli. The percentage of undistinct annuli is 1-2 per cent on sections of finrays, as compared to 15-20 per cent on scales (Lucioperca lucioperca, Abramis brama, Pelecus cultratus).

Age determination from sections of finrays usually presents no difficulty and can easily be carried out by technical assistants without any prolonged training, whereas scale reading requires a great deal of practice, though, as we know, even this does not always prevent errors.

The better visibility of annuli on sections of finrays as compared with scales, and the possibility of treatment of mass collections of fins permit to adopt the method described as the principal or even the sole method of age determination of many fish species. At the Don-Kuban Experimental Fishery Station over 55,000 fins of Lucioperca lucioperca, Abramis brama, Pelecus cultratus and Rutilus rutilus Heckeli were worked up by the end of July 1945, not to mention other fishes; scales have now been scarcely ever used for age determinations. The age of Acipenseridae, Silurus and Cyprinus carpio is determined from sections of the hard finray.

The question as to the possibility of back calculations of the rate-growth has not been investigated, though such calculations are practised from sections of finrays of Acipenseridae and Silurus. For other fishes only single attempts have been made, some of which (7,8,9) proved successful.

The Don-Kuban Experiment
Fishery Station. Rostov Don.

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# TRASH FISH UTILIZATION IN UTAH

The July-August 1948 issue of this publication carried an article discussing the processing of trash fish in Utah. During the interim this work has continued and has made considerable progress. It can safely be stated it has gone by the pioneering state. All the minor vexations have been eliminated so far as the mechanical side is concerned. When the plant first operated considerable amounts of impurities remained in the oil. Too much oil remained in the meal and the disposal of body water or stick became a problem. New rotary presses were added to the equipment. This removed much of the fine meal. It was not until two large De Laval separators were added to the equipment that the best quality of oil was produced. The first separator or slusher as it is called removes the body water and part of the fine meal. When the oil is run through the last separator pure spring water is added, resulting in a thorough washing of the oil and a final separation. This leaves pure fish oil of finest quality. It is now ready for the market.

The fish meal is of highest quality and is in such demand that the market cannot nearly be satisfied. However, the Utah State Fish and Game Department, through a gentleman's agreement, has first priority on fish meal.

The valuable product fabricated in processing the trash fish is body water or stick as it is sometimes called. This contains vitamins A and B, according to Mr. Lloyd. But at the present time no attempt to recover it is made at this plant. It is at present disposed of as a fertilizer.

Your editor wishes to make a correction of an error found in the July-August, 1948, issue of this bulletin. It was stated the body water was impregnated with vitamins and was used in the manufacture of oleomargarine. This statement was based upon inaccurate information. Investigation indicates stick water is used in no food product.

In addition to the improvements made at the processing plant several ingenious devices have been installed at the seining operations. Seines are drawn in with small power winces. The fish are unloaded with a large power dip net holding two hundred lbs. to the haul. A large crate supported by inflated pontoon rafts has a capacity of 12 tons and is emptied with a power elevator directly into the trucks. The future of the fish processing plant will lie in the ability of Utah waters to furnish large quantities of fish.

## Effect of Trash Fish Removal

Any biologist will tell you there is room in a given area for so many units of life. If that area happens to be a lake and is more given to the growth of trash fish than to the game fish, then the game fish population will suffer. That seems to be the case in several of Utah's lakes.

It amazes one when he learns that over 700 tons of trash fish have been removed from Strawberry lake already. It is believed by some that the effect of this upon the trout population can already be observed. One notable effect in the removal of the quantity of fish stated above is the increase in the size of them. It is safe to say they will average one-third more in weight than when seining operations began. This alone indicates the lake had more fish than it could support.

Deer Creek Reservoir has very rapidly filled up with chubs, carp and perch.

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Reprinted from Utah Fish and Game Bulletin 7 (6): 1, 4-5. August 1949.

See also: "New Industry in Utah Utilizes Trash Fish" (Utah Fish and Game Bulletin 5 (12): 6-7. July-August 1948), reprinted in THE PROGRESSIVE FISH-CULTURIST 11 (1): 85-86, January 1949.

The Fish and Game Commission is very anxious to have this body of water seined of the trash fish and also the immense perch population. The State Legislature, however, has decreed perch to be game fish and this leaves the Game Commission powerless to remove them. It is not practical to seine the trash fish and sort out perch.

The Fish and Game Commission appealed to the Attorney General for a ruling to permit the seining of perch from Deer Creek, along with the trash fish. The Attorney General states in his decision that he is powerless to rescind the law made by the Legislature and can find no place in any other law that would give the Fish and Game Commission power to permit the removal of perch from Deer Creek along with the trash fish.

It will be necessary to appeal to the next State Legislature to get perch declared a trash fish in all or certain waters.

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Apparently the grayling in the U. S. S. R. is a more voracious feeder than our American species. When the stomachs of 2,486 graylings taken from the Ilych River were examined, 10.5 percent contained 270 shrews and 5 field mice. Shrews, taken at night when they crossed the river, appeared most frequently in the stomachs of graylings collected during the summer.

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The activities of the Great Lakes Sea Lamprey Committee have included some investigation of the feasibility of utilizing the Great Lakes sea lamprey for the market. Apparently, however, this eel-shaped parasite that has caused considerable damage to the fishing industry and the sports fisheries of the Great Lakes within the last 15 years cannot be regarded as a potential source of food, oil, or vitamins. Preliminary analyses indicate that the vitamin A potency and the oil yield are much too low for commercial exploitation. Moreover, because this sea lamprey is extremely susceptible to fungus infection and its body is very soft, most of the cooking tests made thus far have proved unsatisfactory. One canning test made in Canada has given some promise of success, however, and there is a possibility that this predator upon valuable fresh-water fish may be suitable for reduction purposes.

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# ABSTRACT

## *AMERICAN FISHERIES SOCIETY*

THROUGH the courtesy of Mr. George E. Sprecher (Secretary-Treasurer) and Dr. Lloyd L. Smith (Chairman of the Editorial Board), we have been permitted to publish the following abstracts of papers presented at the 79th Annual Meeting of the American Fisheries Society:

### RADIOACTIVE WASTES AND THEIR SIGNIFICANCE IN STREAM ECOLOGY

Elmer Higgins
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Washington, D. C.

The problem of devising safe means for the disposal of radioactive wastes has long concerned the United States Atomic Energy Commission, but no completely satisfactory solution has been found. The nature and sources of such wastes and methods of handling are reviewed.

Aquatic organisms, perhaps more than any other group of organisms, are directly exposed to radiation hazard from the wastes of atomic energy operations and may be subjected to long-continued low-level exposure. The effect on organisms of such low-level radiation, as a feature of the relatively constant environment, has received very little study owing, in part, to the difficulties of experimental observation.

A tributary of the Clinch River, Tennessee drainage, which has been receiving minor quantities of radioactive wastes for some time and which contains an apparently normal flora and fauna including abundant plankton and a mixed warm-water fish population, has been selected for ecological study. Adjacent waters of the Tennessee drainage are unpolluted and, therefore, offer suitable areas for the comparison of conditions of life in contaminated waters. The principal problems to be investigated and the methods of ecological study, including quantitative changes in population-composition and density, are outlined and progress in initiating the study is described.

Radiation from radioactive wastes is a new element in the ecology of some streams which must be taken into account.

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### SOME TESTS WITH EXPERIMENTAL GROUPS OF FINGERLING RAINBOW TROUT, *Salmo gairdnerii*, ON UNIFORMITY AND RATE OF GROWTH, DIET, AND PHOTOGRAPHIC SIZE-RECORDING

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The paper deals with certain techniques of measuring differences in groups of experimental fish such as might be used in testing hatchery diets or environmental factors. In an experiment of 2 months' duration, nine similar groups of fish were weighed as groups at weekly intervals, and measured individually on four occasions to determine the degree of uniformity in growth attainable under experimental conditions. The standard deviation of length for each group maintained a fairly constant relationship to the other groups. Rate of growth was rapid. The average weight in grams at any time equaled $(2.9594)\ (1.2378)^{\underline{t}}$ where the exponent $\underline{t}$ is time in weeks. The 20-ingredient diet is tabulated with percentages; an over-all food conversion factor of 3 to 1 was obtained. Substitution of halibut viscera for 20 percent

of the regular diet in four of the groups reduced the rate of growth significantly and was discontinued after 3 weeks. A group-photographic method of recording size was tested and found inferior to manual measuring of length for general purposes, although it had advantages in speed of obtaining a permanent record of size and general appearance. Tests of three of the length-frequency distributions showed them to be approximately normal.

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## WHITE BLINDNESS IN HATCHERY BROOK TROUT[1]

Leonard N. Allison
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White blindness is a hitherto unreported dietary disease in which brook trout assume a very pale body color, the crystalline lens of the eye softens and becomes an opaque, milky color, and blindness results. Normally, blind trout become dark in color. Loss from the disease, however, is only moderate in hatchery ponds. It was first observed in the spring of 1946 at the Baldwin Trout Rearing Ponds, Baldwin, Michigan, among yearling fish. It appeared in fish of the same age at certain other trout stations in Michigan in 1947 and 1948. An analysis was made of the diets in use at the stations where the malady appeared and at stations that were free of it. This study demonstrated that white blindness of brook trout was present where the fish were fed 27.2 percent or more horse products and absent where the fish were fed 18 percent or less horse products. One station feeding 90 percent horse liver showed a high percentage (30 percent) of blindness among brook trout. Experiments are now in progress to determine whether any single horse product (hearts, liver, meat or skeletal muscle, or cooked meat) may be responsible for the disease. Brown and rainbow trout are not affected.

1/Contribution from the Michigan Institute for Fisheries Research.

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## SOME CONSIDERATIONS IN THE USE OF FISH GROWTH DATA BASED UPON SCALE STUDIES[2]

Kenneth D. Carlander
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In comparing growth data, it is frequently necessary to convert standard lengths to fork or total lengths. A study of the deviations observed from calculated lengths in three series of data using various conversion factors indicated that with samples of 15 or more fish the errors of conversion will usually be less than 1 percent when the conversion factors are based upon the same fish or fish from the same area measured by the same biologist. When the conversion factors are based upon fish from other areas measured by other biologists, the error may be as much as 4 to 5 percent. The differences in body-scale relationships between fish of the same species from different collections make further study necessary. Studies of the scales of the perch indicated variation of scale radii up to 100 percent of the mean scale radius. Care should be taken in selecting scales for growth studies. A standard deviation of about 3.5 percent was noted in calculated growths from paired scales from several series of fishes. Comparison of length at capture avoids errors due to body-scale relationship but introduces difficulties due to differences in time of capture. It is suggested that lengths at time of last annulus might be more valid for comparative purposes. By using the coefficients of variation from three growth studies it was calculated that variations between calculated growth rates of fish from the same population are such that samples of about 240 are needed to bring the sample mean within 1 percent of the true mean with 95 percent confidence.

2/From the Iowa Cooperative Fisheries Research Unit, sponsored by the Iowa State Conservation Commission and the Industrial Science Research Institute of Iowa State College, with the cooperation of the U. S. Fish and Wildlife Service.

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